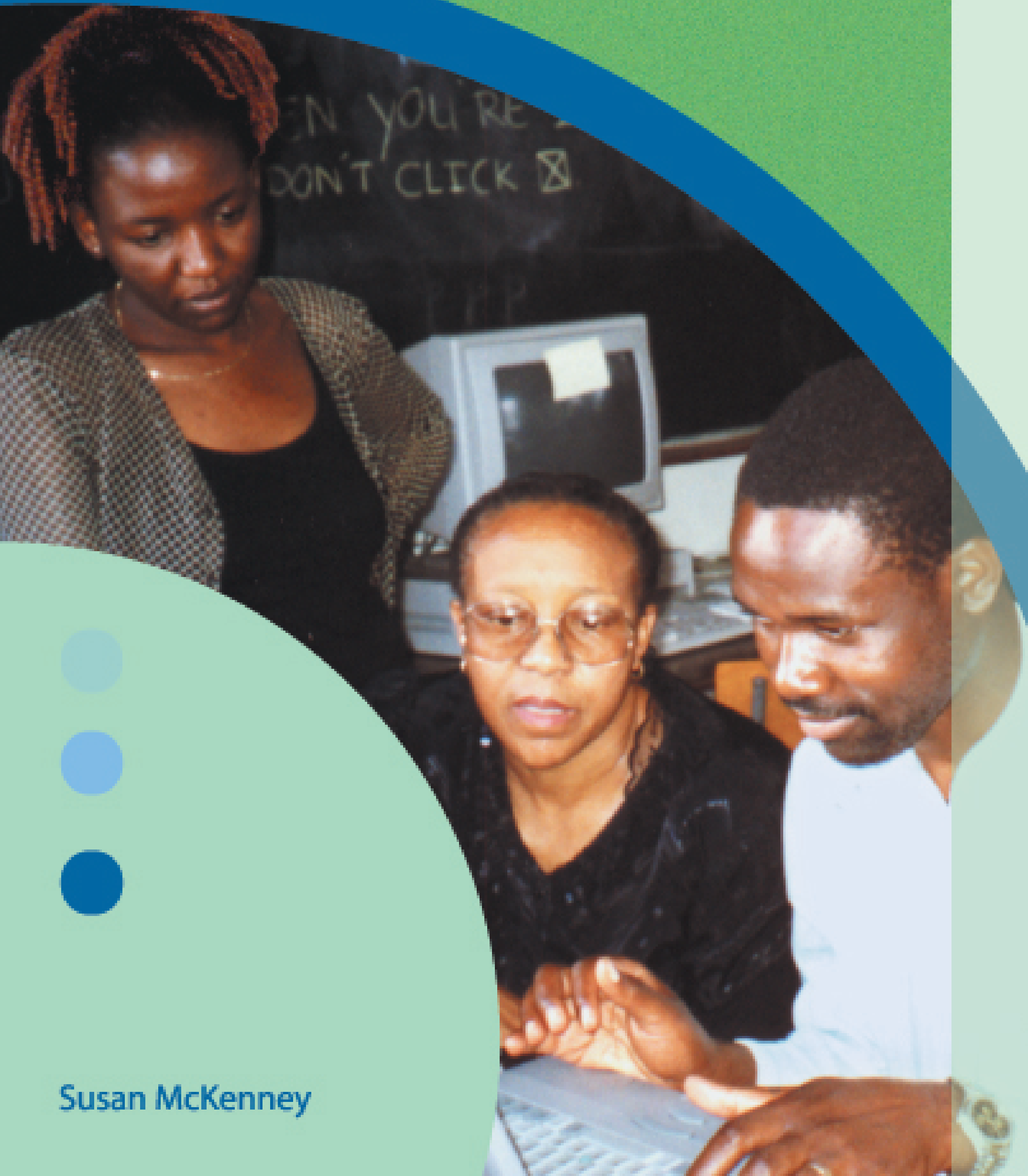
Computer-Based Support for Science Education Materials Developers in Africa

exploring potentials



Susan McKenney

Computer-Based Support for Science Education Materials Developers in Africa: Exploring Potentials

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COMPUTER-BASED SUPPORT FOR SCIENCE EDUCATION MATERIALS DEVELOPERS IN AFRICA: EXPLORING POTENTIALS

PROEFSCHRIFT

ter verkrijging van
de graad van doctor aan de Universiteit Twente,
op gezag van de rector magnificus,
prof. dr. F.A. van Vught,
volgens besluit van het College voor Promoties
in het openbaar te verdedigen
op vrijdag 12 oktober 2001 te 16.45 uur.

door

Susan Emily McKenney

geboren op 4 november 1968
te Chester County, Pennsylvania, USA

Promotoren:
Prof. dr. J.J.H. van den Akker
Prof. dr. Tj. Plomp

In memory of my most inspiring teacher, my mother

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Foreword

Preface

Kawia ufike - be late, but get there - says the Swahili proverb. The course of this research has taken me many places, both figuratively and literally. As I near my destination, it is with great pleasure that I look back on the opportunities it has offered. Above all else, this journey has brought me into contact with people who have challenged, inspired and guided me in my personal and professional growth. For this, I am truly grateful.

This study would not have been possible without the support and encouragement of many individuals and organizations. In addition to those listed in the acknowledgements, I would like to thank a small group of people in particular. The characteristically warm welcome of my friends and colleagues at the TEAMS program in Tanzania has indelibly marked my impressions of this study, especially since this group was involved throughout the each stage of its evolution. Special thanks go to Funja Osaki and Andrew Clegg for their enduring hospitality and good-natured collaboration. I have enjoyed learning from and interacting with them both, during as well as after workshop hours. Likewise, Kenneth Chavunduka and Ernst Engels hosted many a visit to the SEITT project in Zimbabwe. Their repeated willingness to take part in this exploration has been both enjoyable and enriching.

I thoroughly welcomed opportunities to conduct this study's fieldwork in person, although I was not always alone in this task. I am grateful to ten graduate students who carried out sub-studies within this research. As the first students I had the privilege to mentor, I learned a great deal from Eveline van Daele and Annemieke van Keulen during their study of the Tanzanian context, which helped clarify the status quo of activities within teacher resource centers. I am grateful to Annet van de Put, who traveled to Zimbabwe in a dedicated effort to evaluate the third prototype of CASCADE-SEA. It has been a joy to work with Patricia Madzima, who taught me many things about her country while she explored applications for CASCADE-SEA in Zimbabwean teacher training colleges. Hard work during her evaluation in Tanzania, coupled with a healthy sense of humor made cooperation with Eugenia Kafanabo always a pleasure. Thelma van der Laan's commitment and genuine collaborative spirit helped her to conduct valuable explorations into the use of CASCADE-SEA in South Africa. The positive attitude and perseverance of Natasja Nijhof and Andrea Wagenaar during and after their work in Namibia were both energizing and insightful. Investigation into the suitability of CASCADE-SEA in inservice education in South Africa was served, no doubt, by the relentless energy and cheerfulness that characterizes Noer Wuisman and Caroline Timmers. Each of these individuals worked both independently and cooperatively, and I am truly appreciative of their participation.

What a delight it has been to go to work regularly with a smile on my face. To a great extent, I owe this to the good fortune of having wonderful colleagues. I would like to thank the Department of Curriculum staff for their constructive criticism, stimulating conversations and for creating an environment that is typified by team spirit. Petra Zuithof and Paula Krupers-Achterberg have both provided various forms of administrative support not only during the writing of this dissertation, but throughout the entire study. I look forward to continued cooperation with Wilmad Kuiper, who frequently offered his insights and critique during various stages of the research. Together with his programming expertise, Ben Reimerink's gentle disposition and tenacity made him an invaluable asset to the development efforts. Irene Visscher-Voerman has been a bountiful source of moral support and positive energy, not to mention friendship. Likewise, I have valued and admired Nienke Nieveen's professionalism and encouragement; she has been an outstanding coach and comrade. I fondly recall many memories created with Annette Thijs in and out of our office, in the USA and in various African settings. Since my first day in the department, she has been my sounding board, sparring partner and - most of all - friend.

It has been a privilege to work and learn under the tutelage of such inspiring and dedicated supervisors. In addition to our spirited debates, I am grateful to Tjeerd Plomp for his reliable pragmatism and continued support. As my daily mentor, Jan van den Akker offered me exceptional growth opportunities. He granted me room for creative exploration, yet reined me in when I needed it. Between the two of them, I could not have asked for a richer, more stimulating and enjoyable experience.

I consider myself fortunate to have benefited from the patience, love, humor and encouragement of such faithful friends and family. Thank you very much. And finally, I would like to express my gratitude to Kevin, who has tended my soul and held my compass throughout this journey.

Enschede, October 2001

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Many individuals and organizations contributed to this study. In addition to those who participated directly, others offered support or facilitated events. Together, these people helped to shape both the process and the product of this research. I would like to express my gratitude to them all.

In chronological order of involvement:

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- The participants in the hands-on session held at the Regional Workshop on Developing Teacher Leadership for Curriculum Innovation in Mathematics and Science in Manzini, Swaziland;
- Jeannette Vogelaar, Patricia Madzima and their colleagues at UNESCO and the Zimbabwe National Commission for UNESCO who helped organize workshops in Harare, Gweru, Mutare and Masvingo;
- Steve Mahere, Ted Sells and their colleagues at the Zimbabwean Ministry of Education, Sport and Culture for their continued support and enthusiasm for the study;
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- The Johannesburg teachers who gave up precious summer holidays to attend the University of Witwatersrand workshop in Johannesburg;
- Workshop participants at the Curriculum 2005: Rhetoric and Reality conference who promulgated various site visits and evaluation opportunities;
- Andrew Clegg, Claudia Tjikuua and their colleagues from the Human Resources Development project who organized the seminar at the Namibian Ministry of Education, as well as those who attended;
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- Joanne Capper and Yoshiko Koda at the World Bank for their support, and for granting opportunities to exchange ideas with them and others during various visits;
- Exploratory query participants who took the time to install, use and reflect on CASCADE-SEA, as well as write and send their comments;
- Brian Gray, Patrick Whittle and David Waddington for their suggestions and for facilitating the integration of materials from the *Harare Generator* into the CASCADE-SEA program;
- Michael and Bettina Jetter, Stefan van As, Mark Lister and Kevin Daniel for their encouragement and assistance as well as for granting permission to freely distribute their software (Mindman, Knowledge Display, Satori and Image Forge, respectively) along with the CASCADE-SEA program;

- Ms. Madzima, Ms. Matikiti and Mr. Vundla (front cover, left to right) and Mr. Dzumbunu, Mr. Musekiwa and Mr. Nyoni (back cover, top to bottom) for allowing me to take and use their pictures;
- Ron Jensh for capturing various cascades on film (back cover).

English and Dutch Summaries

Computer-based support for science education materials developers in Africa: exploring potentials

CASCADE-SEA stands for Computer Assisted Curriculum Analysis, Design and Evaluation for Science (and mathematics) Education in Africa; and is the name of a computer program that was developed during the course of the study described in this book. This research was initiated to explore the potential of the computer to support curriculum materials development within the context of secondary level science and mathematics education in southern Africa. By carefully documenting the iterative process of analysis, prototype design, evaluation and revision, insights were sought with regard to the characteristics of a valid and practical tool that possesses the potential to impact the performance of its users. The results of this study include the concrete output of the CASCADE-SEA system, which assists users in producing better quality materials than they otherwise would (without the aid of this tool) while learning from the development process. This research has also contributed to the articulation of design principles and related development research methods.

Background

Although various factors influenced the inception of this study, three driving forces provided the greatest momentum: the rapid growth of Electronic Performance Support Systems (EPSSs), a previous Dutch study into the field of computer supported curriculum development, and increased partnerships with various agents of curriculum reform in southern Africa. Ever since the 1980s, when personal computer use started to become ubiquitous in professional settings, exploration has been underway into how the computer might be able to support the performance of various tasks. This has led to the concept of EPSS, in which performance support is provided for a particular (set of) task(s) through electronic means. Although definitions vary, most EPSSs offer: tips and advice, tools and templates, learning opportunities, and communication. Especially for those systems that aid in the execution of complex tasks (such as curriculum development), individuals and organizations stand to benefit from such tools.

To learn more about the computer's supportive role in curriculum development, the University of Twente's Department of Curriculum within the Faculty of Educational Science and Technology launched a research project in 1993, called CASCADE (Computer Assisted Curriculum Analysis, Design and Evaluation). In collaboration with the Dutch National Institute for Curriculum Development (Dutch acronym: SLO), this study explored ways to support relatively quick and easy formative evaluation of curriculum materials. The results showed that that the program developed for this purpose - CASCADE - helps users to improve the consistency of formative evaluation plans and activities, motivates developers by elevating their confidence in being able to conduct formative evaluation tasks, saves time and helps to provide justifications for resulting decision-making. Such findings were encouraging, and prompted a small-scale exploratory study, which showed that a CASCADE-like system had potential value outside of the context for which this program was originally developed. (For additional information regarding the CASCADE program and findings, please refer to Nieveen, 1997.)

During CASCADE's evolution, the same group of researchers became increasingly involved in curriculum development initiatives in the southern African region. As the exchange of information, problems and potential solutions began to occur between Dutch and African institutions, a line of inquiry started to take shape. Could the computer possibly offer support to African curriculum developers? Might the existing research in this arena provide a valuable springboard? What would be a feasible route to finding out? Together with the input from international colleagues, the decision was made to explore how an EPSS might be able to address some of the challenges faced by curriculum materials developers in southern Africa.

Conceptual framework

Based on the notion that curriculum development and teacher professional development are two mutually enhancing processes, this study set out to explore how the computer might be able to contribute to and even enhance the synergy that exists between the two, at a very natural crossroads: the creation of exemplary lesson materials. These ideas are illustrated in Figure ES.1, below. Here, one can see that the arenas of curriculum development and teacher professional development overlap in the process of creating exemplary lesson materials. Further, the notion of computer-based performance support, designed to assist and enhance that process, is also represented. The final element in the model is the support structure in which these activities take place. This study targeted regional teacher resource centers, although teacher training colleges and universities also served as support structures on occasion.

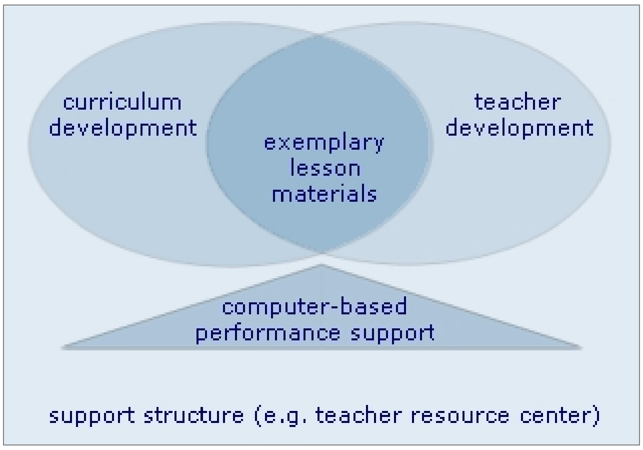


Figure ES.1: Conceptual model used throughout this study

At the beginning of the study and throughout its evolution, guidance was sought from literature relating to curriculum development, teacher professional development, exemplary materials, existing support structures (such as TRCs) and computer-based performance support. Insights from relevant literature along these thematic lines helped to shape the structure of the study as well as the CASCADE-SEA program itself. These ideas were articulated in the form of tenets that served to guide research and development activities. These tenets pertain to the following topics:

- *Local relevance:* any educational innovation must be carefully examined and, if necessary, (re)tailored for the context and culture in which it will be implemented.
- *Collaboration:* design and development activities (related to an innovation) must be conducted in *collaboration with* and not *for* those involved.
- *Authenticity:* efforts must be based on a working knowledge of the target setting and, where possible, research and development should be conducted in naturally-occurring test beds.
- *Mutual benefit:* a skillful attempt should be made to combine research activities with meaningful experiences for the participants.
- *Continuous (re)analysis:* careful and regular analysis of the risks and benefits of the innovation should be conducted in the light of the target setting, with design and development decisions being taken accordingly.

Research design

Because of its natural 'fit' with these foundational tenets, a development research approach was selected to answer the following main research question: *What are the characteristics of a valid and practical support tool that has the potential to impact the performance of (resource) teachers in the creation of exemplary lesson materials for secondary level science and mathematics education in southern Africa?* The quality aspects that are central to this question were carefully defined. Validity refers to a product that contains state of the art knowledge, which is relevant to the tasks it intends to support, and is offered in an internally consistent fashion. Practicality implies usability in terms of practical constraints, in addition to linking up with user needs, wishes, attitudes and beliefs. And indicators of impact are present when positive effects on performance are evident.

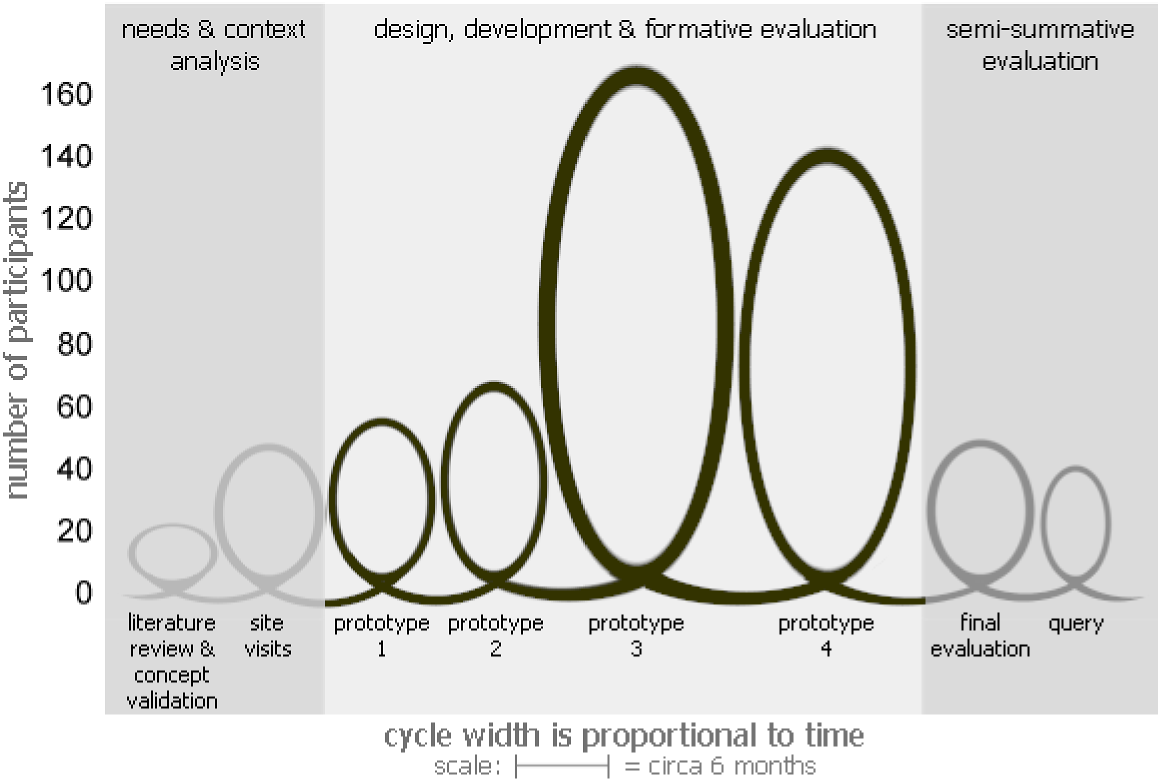


Figure ES.2: Display of the CASCADE-SEA *study*

As illustrated in Figure ES.2 above, the research featured three main phases: needs/context analysis; design/formative evaluation of prototype tools; and a more summative assessment of the final product (including exploration of its value for other contexts). Each phase consisted of multiple cycles of activities involving different groups of (expert and user) participants. In total, eight cycles were conducted with approximately 510 participants from 15 countries (mostly in the southern African region). Participant data were collected throughout the study via 108 instruments of the following types: interview and walkthrough schemes; questionnaires; discussion guides; observation and demonstration schemes; logbooks; and document analysis checklists.

Prototype research and development

The various cycles of data collection activity were undertaken to inform development of the CASCADE-SEA tool and, related to it, the articulation of program characteristics. These characteristics eventually took shape in three layers of abstraction. Foundational tenets were most abstract, highlighting implications of the aforementioned topics (local relevance, collaboration, authenticity, mutual benefit and continuous [re]analysis) with reference to program design. Development guidelines featured criteria pertaining to the content, support and interface of the to-be-designed program based on literature as well as experience and reflection. The most concrete layer was the product specifications, which represented developer ideas on how to achieve the characteristics prescribed (by the foundational tenets and the development guidelines) for the content, support and interface of the program. These principles (which emerged and took shape throughout the study) and the CASCADE-SEA support tool evolved through four prototypes and a final version, fed by participant input. (The final version of the program, along with other files related to this dissertation, is included on the CD-ROM at the back of this book.)

During the analysis phase, participants helped shape researcher/developer understanding of the context, most appropriate user groups to target, and areas (of curriculum development) in which a support tool may be put to work. Subsequently, four prototypes were formatively evaluated (each set of findings influenced ensuing prototypes) during the design and development phase. The last phase of the study mainly examined the impact of the CASCADE-SEA system in terms of (potential) contributions to curriculum development and teacher development resulting from its use. Although not unanimously, participants indicated that CASCADE-SEA does (satisfactorily, not perfectly) meet the criteria of validity, practicality and impact potential.

Conclusions

Through the development of a valid and practical system, this study has shown that the computer does have the potential to positively impact curriculum development and teacher development by supporting the creation of exemplary lesson materials in southern Africa. Users (generally) produce better materials than they otherwise would, and learn from this process due to the program's combination of:

- *Content:* CASCADE-SEA systematically structures the materials development process and illustrates its iterative nature through analysis, design and evaluation activities that are guided by an explicit rationale.
- *Support:* CASCADE-SEA blends generic and tailor-made advice; internal and external tools; implicit and explicit learning opportunities; and written and verbal communication aids to assist the user throughout the materials creation process.
- *Interface:* CASCADE-SEA offers the content and support through a direct, consistent and forgiving visual (and technical) representation, which grants the user both flexibility and control over the process.

The desired quality aspects (validity, practicality and impact potential) are neither absolute nor completely objective. Rather, they are relative to the context in which the program is employed, as well as the needs, expectations and beliefs of individual users. The CASCADE-SEA research has also highlighted the importance of continuously seeking heightened contextual understanding as an integral part of the design and development process. So, in addition to the design principles and program itself, this study has also yielded suggestions for development research of this nature.

Mogelijkheden van computerondersteuning voor lesmateriaalontwikkelaars van exacte vakken in zuidelijk Afrika

CASCADE-SEA staat voor Computer Assisted Curriculum Analysis, Design and Evaluation for Science (and mathematics) Education in Africa, en is de naam van een computerprogramma dat is ontwikkeld gedurende de in dit boek beschreven studie. Het onderzoek had tot doel te verkennen welke ondersteuningsmogelijkheden de computer kan bieden bij het ontwikkelen van exemplarisch lesmateriaal voor de exacte vakken in het voortgezet onderwijs in zuidelijk Afrika. Via een iteratief proces van analyse, prototype-ontwerp, evaluatie en revisie, is gezocht naar kenmerken van een valide, praktisch bruikbaar en potentieel effectief systeem. Behalve een prototypisch product heeft dit onderzoek ook een bijdrage geleverd aan de articulatie van ontwerpprincipes en daaraan gerelateerde ontwerpgerichte onderzoeksmethoden.

Achtergrond

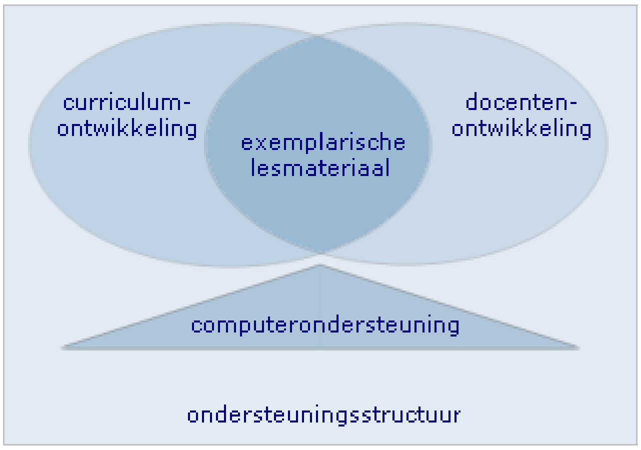
Drie ontwikkelingen zijn van invloed geweest op de totstandkoming van dit onderzoek: de snelle groei van elektronische taakondersteuningssystemen (Electronic Performance Support Systems - EPSSs), een recente Nederlandse studie op het gebied van computerondersteunde curriculumontwikkeling, en een toename aan samenwerkingsverbanden tussen de Universiteit Twente en curriculumvernieuwingsprojecten in zuidelijk Afrika. Sinds de jaren '80, toen het gebruik van de computer op de werkplek begon toe te nemen, zijn verkenningen gaande naar manieren waarop de computer ondersteuning kan bieden bij het uitvoeren van taken. Dit heeft geleid tot het concept EPSS, dat verwijst naar taakondersteuning door elektronische middelen. Hoewel definities variëren, bieden de meeste EPSSs tips en advies, gereedschap en sjablonen, leermogelijkheden en communicatiehulpmiddelen. De veronderstelling is dat met name systemen die ondersteuning bieden bij het uitvoeren van complexe taken (zoals curriculumontwikkeling) een positieve bijdrage zouden kunnen leveren aan het functioneren van individuen en organisaties.

Om meer te kunnen leren over de mogelijkheden van de computer bij het ondersteunen van het curriculumontwikkelingsproces, is in 1993 door de Universiteit Twente een onderzoek gestart, genaamd CASCADE (Computer Assisted Curriculum Analysis, Design and Evaluation). Deze studie, die werd uitgevoerd in samenwerking met het Instituut voor Leerplanontwikkeling (SLO), was gericht op de vraag welke ondersteuning de computer kan bieden bij het plannen en uitvoeren van formatieve evaluatieactiviteiten van lesmateriaal. Het computerprogramma (CASCADE) dat binnen dit onderzoek werd ontwikkeld en onderzocht bleek gebruikers te helpen bij het verbeteren van de interne consistentie van de formatieve evaluatieplannen en -activiteiten, het vergroten van hun zelfvertrouwen op het gebied van het uitvoeren van formatieve evaluatietaken, en het onderbouwen van strategische beslissingen. Deze bevindingen werden veelbelovend gevonden, temeer daar bleek dat het CASCADE-programma ook buiten de oorspronkelijke beoogde context waardevol zou kunnen zijn. (Voor meer informatie over het CASCADE-programma en bevindingen, zie Nieveen, 1997.)

Parallel aan het CASCADE-onderzoek, raakte dezelfde onderzoeksgroep steeds meer betrokken bij initiatieven tot curriculumontwikkeling in zuidelijk Afrika. De uitwisseling van informatie, problemen en mogelijke oplossingen tussen Nederlandse en Afrikaanse instituten leidde ertoe dat een onderzoekslijn vaste vorm kon krijgen. Zou de computer ondersteuning kunnen bieden aan Afrikaanse curriculumontwikkelaars? Zou het eerder uitgevoerde CASCADE-onderzoek hierbij een waardevol uitgangspunt kunnen bieden? Wat zou een geschikte manier zijn om hier achter te komen? Om mogelijkheden te verkennen voor het ontwikkelen van een EPSS dat Afrikaanse curriculumontwikkelaars zou kunnen ondersteunen bij de verschillende uitdagingen waarmee zij in het ontwikkelproces geconfronteerd worden, is in samenspraak met collega's in zuidelijk Afrika besloten om een onderzoek te starten. Het onderzoek kreeg de naam CASCADE-SEA.

Conceptueel kader

In de praktijk van zuidelijk Afrika geschiedt de ontwikkeling van exemplarisch lesmateriaal doorgaans vooral door 'resource teachers.' Het CASCADE-SEA-onderzoek is gebaseerd op het idee dat curriculumontwikkeling en de professionele ontwikkeling van docenten processen zijn die elkaar wederzijds kunnen versterken. Beide processen komen samen wanneer docenten exemplarisch lesmateriaal ontwikkelen. Het onderzoek had tot doel te verkennen hoe de computer de ontwikkeling van dergelijk materiaal kan ondersteunen en richtte zich daarmee op het kruispunt van deze twee processen. Daarbij moet aangetekend worden dat beide processen niet in een isolement plaatsvinden, maar binnen het bredere kader van een ondersteuningsstructuur bestaande uit onder andere regionale nascholingscentra, docentenopleidingen en universiteiten. Figuur NS.1 vat deze ideeën samen. De figuur laat zien dat curriculumontwikkeling en de professionele ontwikkeling van docenten elkaar overlappen in het ontwikkelproces van exemplarisch lesmateriaal. Daarnaast is de rol van computerondersteuning bij dat ontwikkelproces afgebeeld.



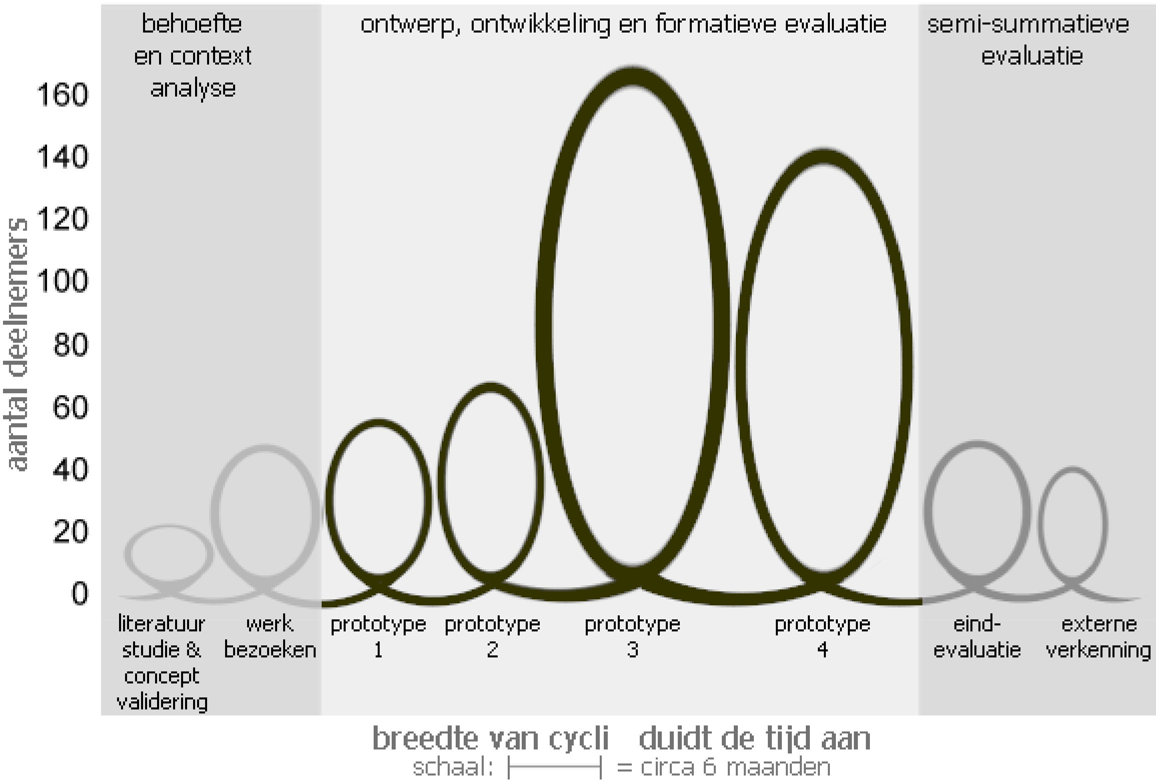
Figuur NS.1: Conceptueel model van deze studie

Aan het begin van het onderzoek en ook gedurende latere fasen is literatuuronderzoek uitgevoerd naar met name de volgende concepten: curriculumontwikkeling, docentenontwikkeling, exemplarisch lesmateriaal, en computerondersteuning. Inzichten uit deze literatuurstudie hebben geholpen bij het vormgeven van de structuur van de studie en het CASCADE-SEA-programma zelf. Op basis van deze bevindingen zijn uitgangspunten geformuleerd die richting hebben gegeven aan de verdere onderzoeks- en ontwikkelactiviteiten. Deze uitgangspunten hebben betrekking op de volgende onderwerpen:

- *Lokale relevantie:* iedere onderwijskundige innovatie moet zorgvuldig bestudeerd worden en, indien noodzakelijk, (her)ontworpen worden voor de context en cultuur waarin zij geïmplementeerd wordt.
- *Samenwerking:* ontwerp- en ontwikkelactiviteiten (gerelateerd aan de innovatie) moeten worden uitgevoerd in *samenwerking met* en niet *voor* de betrokken partijen.
- *Authenticiteit:* activiteiten moeten gebaseerd worden op een grondige kennis van de beoogde context en tevens zouden onderzoek en ontwikkeling zoveel mogelijk in natuurlijke testsituaties moeten plaatsvinden.
- *Wederzijds voordeel:* Onderzoeksactiveiten moeten er zoveel mogelijk op gericht zijn dat ze ook tot betekenisvolle ervaringen van participanten leiden.
- *Continue (her)analyse:* een zorgvuldige en regelmatige analyse van de voor- en nadelen van de innovatie voor de beoogde context, dient te leiden tot adequate ontwerp- en revisiebeslissingen.

Vraagstelling en Onderzoeksontwerp

Vanuit de hiervoor genoemde uitgangspunten is gekozen voor een ontwerpgerichte onderzoeksbenadering ter beantwoording van de hoofdvraag: *Wat zijn kenmerken van een valide, praktisch bruikbaar en potentieel effectief ondersteuningssysteem voor '(resource) teachers' die tot taak hebben exemplarisch lesmateriaal te ontwikkelen voor de exacte vakken binnen het voortgezet onderwijs in zuidelijk Afrika?* Met validiteit wordt bedoeld dat een product 'state-of-the-art' kennis bevat die relevant is voor de gebieden waarin ondersteuning wordt geboden, en die op een consistente manier wordt aangeboden. Praktische bruikbaarheid verwijst naar de mate waarin het product aansluit bij behoeftes, wensen, en attitudes van gebruikers en de mate waarin gebruikers het product kunnen hanteren. Potentieel effectief verwijst naar de mate waarin gebruik van het programma mogelijkerwijs leidt tot betere producten en professionele ontwikkeling van docenten.



Figuur NS.2: Afbeelding van de CASCADE-SEA studie

Het onderzoek bestond uit drie fasen (zie ook Figuur NS.2): behoefte- en contextanalyse; ontwerp en formatieve evaluatie van een viertal prototypes; en een meer summatieve evaluatie van het eindproduct (inclusief exploratie van de potentiële waarde van het product binnen andere contexten.) Elke fase bestond uit meerdere cycli van activiteiten waarin verschillende groepen experts en gebruikers participeerden. In totaal, hebben acht cycli plaatsgevonden met circa 510 participanten uit 15 verschillende landen (met name binnen de zuidelijk Afrikaanse regio.) Dataverzameling vond plaats met behulp van 108 instrumenten, te weten interview- en 'walkthrough'-schema's; vragenlijsten; discussieleidraden; observatie-schema's; logboeken; en checklists voor documentanalyse.

Onderzoek en ontwikkeling van prototypes

De verschillende dataverzamelingrondes zijn uitgevoerd om inzicht te verkrijgen in belangrijke kenmerken van het CASCADE-SEA-systeem. Deze kenmerken zijn uiteindelijk op drie abstracteniveaus geformuleerd: algemene uitgangspunten, ontwikkelrichtlijnen, en productspecificaties. De uitgangspunten zijn het meest abstract en benadrukken de implicaties van de voornoemde thema's (lokale relevantie, samenwerking, authenticiteit, wederzijds voordeel, en continue (her)analyse) voor het ontwerp van het programma. De ontwikkelrichtlijnen bevatten criteria voor het vormgeven van de inhoud, ondersteuning en gebruikersinterface van het programma, en zijn gebaseerd op zowel literatuur als ervaring en reflectie. De productspecificaties bevatten concrete aanwijzingen over hoe de gewenste kenmerken (zoals verwoord in de uitgangspunten en de ontwikkelrichtlijnen) van de inhoud, ondersteuning en gebruikersinterface van het programma gerealiseerd kunnen worden.

Tijdens de analysefase droegen diverse participanten bij aan het greep krijgen op de context, mogelijke gebruikersgroepen en gebieden (van curriculumontwikkeling) waarbinnen een ondersteuningssysteem nuttig zou kunnen zijn. In de hierop volgende ontwerp- en ontwikkelfase zijn vervolgens vier prototypes ontworpen en formatief geëvalueerd (uitkomsten van evaluatie-activiteiten vormden steeds de basis voor het ontwikkelen van de volgende prototypes.) De laatste fase van de studie was voornamelijk gericht op het verkennen van de potentiële impact van de eindversie van het programma. (Deze versie, samen met andere bestanden die horen bij deze dissertatie, zijn opgenomen in de CD-ROM achter in dit boek.)

Conclusies

Binnen dit onderzoek is een programma ontwikkeld dat door experts en gebruikers als valide en praktisch bruikbaar is beoordeeld. Het oordeel luidt dat het in potentie gebruikers kan brengen tot betere exemplarische lesmaterialen en dat het tevens bijdraagt aan eigen professionele ontwikkeling. De volgende combinatie van programmakenmerken lijken hieraan een bijdrage te hebben geleverd:

- *Inhoud:* CASCADE-SEA structureert het ontwikkelingsproces op een systematische manier en illustreert de iteratieve aard van dit proces door de uitwerking van de analyse-, ontwerp- en evaluatie-activiteiten die begeleid worden door een expliciete rationale.
- *Ondersteuning:* Om de gebruiker te ondersteunen bij het ontwikkelen van lesmateriaal biedt CASCADE-SEA een combinatie van: generiek en op maat gemaakt advies; interne en externe gereedschappen; impliciete en

explicite leermogelijkheden; en tekstuele en mondelinge communicatiehulpmiddelen.
- *Gebruikersinterface:* CASCADE-SEA presenteert de inhoud en ondersteuning op een heldere, consistente en een visueel (en technisch) vriendelijke wijze, die de gebruiker zowel flexibiliteit als controle over het proces biedt.

Absolute uitspraken over de beoogde kwaliteitsaspecten (validiteit, praktische bruikbaarheid en potentiële impact) blijken onmogelijk, omdat deze context- en gebruikersafhankelijk zijn. Naast ontwerpprincipes en het programma zelf, heeft het onderzoek ook aanbevelingen voor soortgelijk ontwerpgericht onderzoek opgeleverd.

Chapter 1

About this study

A title such as that on the front cover of this book is likely to raise eyebrows from those aware of the challenging circumstances regarding technological infrastructure in developing countries. This chapter begins to address such skepticism by describing the origins and aims of the study as well as the context in which it took place. It explains that the research described throughout this book has explored the potential value of computer supported curriculum development for science and mathematics teachers in (parts of) southern Africa. Additionally, the main vehicle for the study, the cyclic design, development, evaluation and revision of a computer program that helps materials developers create exemplary lesson plans and teacher guides, is addressed. Finally, the structure of the book is presented.

1.1 Introduction

CASCADE-SEA stands for Computer ASsisted Curriculum Analysis, Design and Evaluation for Science[1] Education in Africa. This acronym is the name of a computer program that was developed during the course of the study described in this book. The CASCADE-SEA program was created through successive prototypes, each one using the lessons learned from the previous versions to (re)build new ones. The cumulative learnings acquired offer insights into design principles for tools of this nature as well as development research methods. Throughout the next six chapters of this book, the impetus for embarking on this study will be explained, the methods and approaches used will be described and the results will be presented. This includes examining the data related to individual prototype

[1] The CASCADE-SEA program (and the study described in this dissertation) targeted both science and mathematics education. However, because the bulk of the composition related to science (biology, chemistry and physics), many descriptions throughout this book imply, rather than specify, the mathematics component.

evaluations as well as the aggregate of findings and their implications. In order to understand and interpret the results and conclusions, it can be useful to begin by discussing how and why this research came to be: its origins.

1.2 Origins of this study

Although various factors influenced the inception of this study, three driving forces provided the greatest momentum: the rapid growth of Electronic Performance Support Systems (EPSSs), a Dutch study into the field of computer supported curriculum development and increased partnerships with various agents of curriculum reform in southern Africa. Ever since the 1980s when personal computer use started to become ubiquitous in professional settings, exploration has been underway into how the computer might be able to support the performance of various tasks. The University of Twente's Department of Curriculum within the Faculty of Educational Science and Technology joined this exploration in 1993, with the launch of a research project that focused on learning more about the computer's supportive role in curriculum development. During this study's evolution, the same department became increasingly involved in curriculum development initiatives in the southern African region. As the exchange of information, problems and potential solutions began to occur between Dutch and African institutions, a line of inquiry started to take shape. Could the computer possibly offer support to African curriculum developers? Might the existing research in this arena provide a valuable springboard? What would be a feasible route to finding out? The next section describes how these (and other) questions arose.

1.2.1 Computer-based performance support

Although the term, EPSS, may be less known, the notion of computer-based support is familiar to most members of contemporary society. In this 21st century, people have come to expect that the computer will be able to help to carry out various tasks. Thanks to the dawn of Internet and the onset of affordable home computers, it has become natural to turn to electronic sources for help with everything from preparing one's taxes to deciding what kind of camera to buy. Many of these tools are forms of EPSS. An EPSS provides performance support for a particular (set of) task(s) through electronic means. Although definitions vary, most EPSSs offer: tips and advice, tools and templates, learning opportunities and communication. All four of these aspects are usually intertwined and structured to aid in carrying out a certain task. Proponents of EPSS presume several advantages of computer-based systems over other forms of support, especially for those systems that help in the execution of complex tasks.

(For detailed information on the advantages of EPSSs, please refer to Chapter 2.) In the field of education, many tasks are complex and numerous individuals and organizations stand to benefit from carefully constructed EPSSs.

1.2.2 CASCADE

One complex task that remains integral to most educational initiatives (in one form or another) is that of curriculum development. In an effort to learn more about the potential of EPSSs for aiding in this process, the Department of Curriculum within the Faculty of Educational Science and Technology at the University of Twente conducted a study in collaboration with the Dutch National Institute for Curriculum Development (SLO). This research was founded on the notion that exemplary lesson materials can play an important role in realizing educational change, and that support to the developers of such materials could assist in improving their overall quality. Previous studies had demonstrated that specific activities could be performed during the process of materials development in order to improve the quality of the output, such as formative evaluation and - based on those results - revision (cf. Nieveen, 1997). Yet, while the concept of formative evaluation is familiar to many curriculum developers, research has shown that such activities are often neglected in the development process. The materials developers (curriculum developers) at the SLO were, in this sense, no exception (van den Akker, Boersma & Nies, 1990). This group indicated that such evaluations are seen to be complex and time-consuming. As a result, opportunities for small-scale efficient evaluations were often under-used.

This first study thus explored ways to support relatively quick and easy evaluation efforts, with the hope that by making such activities less daunting, they might be undertaken more often. It took place through the design, development and evaluation of an EPSS called CASCADE (Computer Assisted Curriculum Analysis, Design and Evaluation), that focused on supporting formative evaluation tasks within the SLO. From this study, Nieveen (1997) concluded that the use of the tailor-made program, CASCADE, could:

- improve consistency of evaluation plans and activities by helping to structure decision-making as well as aiding in weighing options;
- motivate developers and offer reassurance in one's ability to conduct formative evaluation activities, in part by offering an overview of such activities;
- save time by offering assistance in developing a framework for an evaluation plan and by offering sample documents (such as evaluation instruments) that can be adjusted for one's own situation;

- support the underpinnings of decisions regarding the design and execution of evaluation by offering explanations about the concepts used.

Such findings were encouraging, and prompted a small-scale exploratory study that aimed to determine if other settings (outside of the SLO) might benefit from such a tool. This study showed that a CASCADE-like system had potential value outside of the context for which this program was originally developed. (For additional information regarding the CASCADE program and findings, please refer to Nieveen, 1997.)

1.2.3 Ongoing collaboration in southern Africa

At the same time, dialogue between the University of Twente's Department of Curriculum and curriculum development units (often based in universities) in southern Africa began to accelerate. Inter-departmental cooperation was centered on curriculum development issues, and shared research interests became apparent. Participation in and affiliation with curriculum development efforts served to broaden the scope of thinking in terms of other settings in which an EPSS for curriculum development might be useful. In particular, individuals associated with the following programs and institutions contributed to the inception and elaboration of this line of inquiry:

- AMSTIP: Accelerated Mathematics and Science Teacher Improvement Project in Lesotho
- INSTANT: INService Training for Namibian mathematics and science Teachers
- SEITT: Science Education Inservice Teacher Training project (Zimbabwe)
- TEAMS: Teacher Education Assistance for Mathematics and Science (Tanzania)
- UB-INSET: University of Botswana Inservice Education and Training programme for science and mathematics teachers

Together with the input from international colleagues, the decision was made to explore how an EPSS might be able to address some of the challenges faced by curriculum developers in southern Africa. Toward understanding this decision, it may be useful to begin by describing what those challenges are. The next section briefly illustrates the setting in which the CASCADE-SEA study took place: southern Africa. It examines the status quo of science education in sub-Saharan Africa, in particular. In addition, because the bulk of the research activities took place in South Africa, Tanzania and Zimbabwe, these contexts will be described in further detail.

1.3 Context Information

1.3.1 Trends

Ever since the second World War, and increasingly so after the launch of the Sputnik, many nations around the globe have come to associate high investment in science, mathematics and technology education with economic growth. In a review of empirical evidence on the number of scientists and engineers that have been trained in different countries over the past 25 years, Caillods, Göttelman-Duret and Lewin (1996) relate that information to GNP and GNP per capita statistics. They conclude that investing in science education is a necessary (though not sufficient) condition for economic growth. Yet, lessons can still be learned from countries like Korea, China/Taiwan, Hong Kong, Malaysia, Indonesia and Mauritius who have enjoyed rapid economic growth in recent decades. For example, in addition to sound macro-economic policies and heavy investment in human capital, Caillods, et al. (1996, p. 18) cite technology acquisition, which has been accompanied by "substantial investments in education and training in general, and science and technology in particular," as a major contributing factor. While the exact causes for these developments are multi-dimensional and complex, the sustained commitment to science and mathematics education that has remained strong throughout the last 30 years is likely to have played an important part.

Also within the last few decades, many countries in southern Africa have achieved independence. With the hope for a brighter future, countries in this region of the world have often chosen to invest heavily in science and mathematics education. In the domain of science, mathematics and technology education, as well as others, this has resulted in various developments such as new curricula, new subject syllabuses, and reform concerning teaching methodologies (such as a call for more learner-centered teaching).

Post-independence reform efforts carry promise and optimism. Yet they require immense investments with regard to the development of expertise, in order to reach fruition. To complicate matters, many countries in this region of the world have to make due with an un(der) qualified teaching force (Caillods, et al., 1996). This already grave problem can be compounded when educational change demands the inclusion of subject matter completely new to practicing teachers and/or the adoption of a new (usually unfamiliar) teaching methodology. This is often the case when more equitable access to education is part of the reform agenda. For example, when Namibia gained independence in 1995, black and colored teachers who, under the South African apartheid regime, were not permitted to learn about science, were suddenly required to teach it. Furthermore, they were to do so in a learner-centered fashion, a notion totally foreign to most teachers. While there is little argument regarding the inherent value of developments like this, they will only have a chance of succeeding when the challenges and problems presented by these changes are carefully addressed (cf. Ottevanger, 2001).

Many curriculum development efforts have been initiated throughout the region to help cope with post-independence changes and challenges. In the arena of science and mathematics education, three recurring themes within such innovations can be discerned: improvements in preservice teacher education, the establishment/improvement of sustainable inservice education and the more general aim of capacity building among key players (such as curriculum developers). Various methods have been used to achieve these aims, one of which has been the creation of exemplary classroom materials. By engaging educators in the process of designing and reflecting on what should be going on inside the classroom, they also have an opportunity to (1) update their subject matter knowledge, (2) strengthen their basic teaching skills and (3) begin to understand and implement more innovative teaching methods. At the same time, sharing the materials among other educators (regional or national colleagues) can assist in implementing the new curriculum.

While some of these improvement efforts are engaged in replacing out-dated or irrelevant classroom materials, others strive to fill a profound void of teaching resources. In both cases, it is this activity, creating good quality curriculum materials, which is supported by CASCADE-SEA. This EPSS helps materials designers[2] to think about what kinds of materials are needed/wanted most, to reflect on how they should be designed, to develop paper-based teacher guides and to conduct a formative evaluation of the guides or lesson plans that have been developed. Throughout this process, it is hoped that the users of the system will learn from the experience, while they work to provide a valuable resource to a wider audience. In this sense, the EPSS contributes to two developments at once: teacher professional development (by stimulating reflection and learning) and curriculum development (by resulting in exemplary lesson materials). While the aforementioned trends represent similarities regarding the status quo of curriculum development, teacher development and the use of ICT (Information and Communications Technologies) in southern African

[2] Throughout this study, three groups of materials designers (users) are distinguished: preservice teachers, inservice teachers and curriculum developers. Within the middle group is the sub-set of resource (or facilitator) teachers working in the field of inservice education (often active teachers, themselves). Although this study explored how CASCADE-SEA could be used by all the aforementioned groups, the resource teachers have been the primary target group.

educational systems, there are also many differences within and between individual countries. Details relating to these issues in the countries most involved in this research are offered next.

1.3.2 Countries most involved in this study

Republic of South Africa

Figure 1.1: Map of South Africa (CIA, 2000)

Over 40 million people live in the Republic of South Africa. Its vast interior plateau rimmed by rugged hills and narrow coastal plain covers approximately 1,219,912 square kilometers. The black (75.2%), white (13.6%), colored (8.6%) and Indian (2.6%) population share 11 official languages, including Afrikaans, English, Ndebele, Pedi, Sotho, Swazi, Tsonga, Tswana, Venda, Xhosa and Zulu. According to the CIA World Fact Book (2000), literacy (age 15 and over can read and write) is about 81%. The Gross Domestic Product (GDP) per capita in 1998 was $2880, although this wealth is distributed quite unevenly.

South Africa's long and complicated history began with Bantu and Bushmen inhabitants before the 17th century, featured power struggles between the Dutch (Boers) and the British in the 19th century, and the practice of separate development of races (apartheid), which became official policy in 1948. The country held elections in which all races could vote in 1994, enabling black nationalist leader Nelson Mandela (representing the African National Congress), to become president. A new constitution was approved in 1997 and is now being implemented in phases.

South Africa's apartheid history left a legacy in the field of education, including 19 Departments of Education, one of which controlled norms and standards that were to be met by the other 18. Since 1995, the ANC has been working to reduce the number of departments to only one National Department of Education, which is now organized and managed on the provincial level (of which there are nine). In 1997, the Department of Education unveiled a plan for better quality and equality in the education system. The drastic changes that are core to this new program, called Curriculum 2005, are rooted in the philosophy of Outcomes Based Education (OBE). The implementation of this innovation relies on the cooperation and motivation of teachers who are expected to prepare their own innovative and creative OBE-style lessons. For detailed information on Curriculum 2005, please refer to National Department of Education, (1997) or Rogan (2000); for additional information on OBE, please see Sanders, McKenney and Van der Laan (1999).

South Africa, like many of its neighbors, suffers from a shortage of qualified teachers. This is especially severe in the domains of science and mathematics, in which blacks were denied education until the fall of apartheid. In recent years, this country has seen a rapid educational expansion with minimal staff and inadequately educated teachers. According to Arnott and Kubeka (1997), only 50% of South Africa's secondary level mathematics teachers hold a qualification in the area of mathematics; for science teachers, this figure is only 42%. However, the same source estimates that roughly 85% of these teachers do hold professional (education) qualifications.

In the face of so many overwhelming challenges, one might suppose the introduction of ICT into the South African educational system to be a low priority compared to other areas. However, this simply is not the case. Just as science and mathematics education are seen to hold immense potential in terms of economic development, high value is also placed on technology. South Africa is unique in terms of its duality characterized by first world advancement alongside third world poverty. While an estimated 67% of schools have no electricity (HRSC, 1997), many others have computing facilities that rival those at local universities. Perhaps it is because of this stark contrast that South Africa seems to struggle between 'keeping up' with global developments while also striving for more equitable access to good education. With this in mind, it becomes more easy to understand why South Africa has a strong commitment to integrating ICT into the educational system: it is seen as a modern vehicle toward improvement. The nine provincial Departments of Education provide resource centers with computers that may be used by teachers; many teacher training colleges and universities also have computing facilities. Access in schools varies greatly, as previously mentioned, and many non-governmental facilities exist. In general, the presence and effective use of ICT in education does exist, but remains scattered (Haddad et al., 2000; van der Wal & Pienaar, 1997). More universal is the desire to contribute to improvement, and the often-found interest in exploring the use of ICT in developing teaching materials. This has been evidenced by the surge in educational development programs and projects that have cropped up in the last five years, many of which look to ICT for support. Please refer to Chapter 3 for information regarding materials development activities in South Africa that have been relevant to this research. (For additional information regarding the education system in South Africa, please refer to Bondesio & Berkhout, 1995).

United Republic of Tanzania

Figure 1.2 : Map of Tanzania (CIA, 2000)

Tanzania is home to over 30 million people, about 21% of whom live in urban settings. The 945,090 square kilometers of terrain varies from plains along the coast, to plateau in the central areas and highlands in the north and south. Most Tanzanians (99%) are native African (of which 95% are Bantu consisting of more than 130 tribes). Kiswahili or Swahili and English are both official languages, although English is the primary means of communication in commerce, administration, and higher education. Arabic is widely spoken in Zanzibar, and many local languages are spoken as well.

Literacy is approximately 68% and the GDP per capita in 1998 was $730. Tanganyika became independent in 1961 (from UK-administered UN trusteeship); Zanzibar became independent two years later. Tanganyika united with Zanzibar on April 26, 1964 to form the United Republic of Tanganyika and Zanzibar; renamed United Republic of Tanzania later that year.

The Ministry of Education and Culture (MEC) and the Ministry of Science, Technology and Higher Education (MSTHE) wield the most political influence on science and mathematics education in Tanzania. They plan and decide on policy that will be translated into action by various parties, including the Tanzanian Institute of Education (TIE). Though in existence under separate governing, TIE was established in 1995 to oversee the school curriculum and to initiate the production of teacher and learner support materials for pre-primary, primary, secondary and teacher education curricula. Mostly staffed by subject area experts, experts agree that there is a need to build capacity and expertise in the arena of curriculum development within this organization (Ministry of Education and Culture, 1995). There are also other projects, programs and institutions that contribute to curriculum development in Tanzania; generally speaking, these groups approach the task from a more grass-roots level. For information regarding these types of efforts as they relate to this study, please refer to the participant sketches in Chapter 3.

In 1974, the Tanzanian government announced a commitment to Universal Primary Education (UPE). Although there was no shortage of problems related to this decision, primary level Gross Enrollment Ratio (GER[3]) did increase from 52.6 in 1975 to 76.2 in 1985 (UNESCO, 2000). Among other things, this resulted in an explosion of enrollment in secondary schools, and caused pupil:teacher ratios to skyrocket. Needless to say, this exacerbated the existing shortage of qualified teachers. In the years to follow, public confidence in educational services began to decline, inequities in access to education by gender and disadvantaged regions grew and inequalities in educational spending were seen at various levels. To combat these issues, the government of Tanzania set-up an Inter-Ministerial Education Task Force in 1997, that produced a Basic Education Master Plan Strategic and Program Framework for 1997-2002. This plan calls for step-by-step expansion of Teacher Resource Centers (TRCs) that are to offer extra facilities and 10 days of inservice education per year to all teachers. Currently, TIE has established seven TRCs, one in each region of the country; these centers are housed at teacher training colleges. In addition, the University of Dar es Salaam's Faculty of Education has established six Teacher Centers (TCs) housed in or near schools. The original intention was to achieve a cascade effect with TRCs serving TCs, but locals indicate no knowledge of further expansion since funding seems to have dried up (van Daele and van Keulen, 1998). For additional information regarding the Basic Education Master Plan Strategic and Program Framework, please refer to Inter-Ministerial Education Task Force (1997).

Compared to South Africa, the use of ICT in education in Tanzania is thinly spread. Few schools have access to computers at all; some TCs are fortunate to have typewriters, tables and chairs, but not all do. TRCs are slightly better equipped, but only occasionally are computers found and with few exceptions, these are outdated or non-functional. The Faculty of Education at the University of Dar es Salaam does have modern computing facilities including satellite Internet access. TIE offices currently feature a mixed bag of old and new computers. Due to their role as the sole (official) producer of curriculum materials for Tanzania, TIE has expended great effort in recent years in trying to allocate funding for desktop publishing facilities. TIE staff have also indicated interest in exploring the use of computer supported curriculum development tools to aid in their materials production, (Kafanabo, 1999). (For additional information regarding the education system in Tanzania, please refer to Buretta, 1995).

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[3] GER as defined by UNESCO (2000): Total enrollment in a specific level of education, regardless of age, expressed as a percentage of the official school-age population corresponding to the same level of education in given school-year.

Republic of Zimbabwe

Figure 1.3: Map of Zimbabwe (CIA, 2000)

Zimbabwe is a country of approximately 11 million people, of which roughly 10% live in Harare, the capital city. The country is mainly high plateau, rising to mountains on the eastern border, and spanning over 390,500 square kilometers in total. The two main ethnic groups are Shona (71%) and Ndebele (16%). The official language is English, while Shona and Sindebele are also widely spoken. Following years of British rule, the country fought for over a decade before finally achieving independence in 1980.

According to various sources (cf. Famighetti, 1997; CIA, 2000), literacy (age 15 and over can read and write English) is about 85%. The Gross Domestic Product (GDP) per capita was $2,400 in 1998.

Responsibility for education in Zimbabwe is divided between the Ministry of Education and Culture (MEC) and the Ministry of Higher Education (MHE). While the MEC is the authority in charge of primary and secondary education, the MHE is responsible for tertiary education, including teacher training. Within the MEC is an organization called the Curriculum Development Unit (CDU), which mainly produces materials and media for use by teachers and schools. For additional information regarding these organizations and programs involved in teacher education and curriculum development, please refer to Chapter 3, which contains descriptions of those groups in Zimbabwe that have been relevant to this research.

Upon achieving independence, the new Zimbabwean government also chose to increase the education of the population by making primary education universal, integrated (blacks, whites and colored together) and compulsory. Over the next decade, primary enrollment grew tremendously. While the GER in 1975 was 70, it soared to 136 in 1985. The resulting increase in secondary enrollment was an expansion from a GER of 7.7 in 1980 to 49.5 in 1990, (UNESCO, 2000). As the number of professionally educated teachers did not grow at the same pace, improvement efforts began to focus not only on the quantity of education, but also on the quality and viability of the education system as a whole. Various governmental and non-governmental education improvement projects and programs sprang up to address this need. (For additional information regarding post-independence educational developments in Zimbabwe, please refer to Chivore, 1986; Dorsey, 1989; and [with specific regard to science education] Hungwe, 1994).

The use of ICT in Zimbabwean education is rapidly increasing. Although many schools remain poorly resourced, it is not uncommon to find modest computer labs for students, especially in more urban areas. Teacher training colleges (TTCs) are usually equipped with at least one or two computers. Those schools and TTCs associated with current programs like the World Bank Institute's World Links for Development (WORLD) and Unesco's Creating Learning Networks for African Teachers are seeing an even more rapid expansion of ICT facilities. The University of Zimbabwe also offers computing facilities, as do the Science and Mathematics Centers (SMCs) that were established by the Faculty of Science Education in each of Zimbabwe's nine regions (two in Harare). Those groups responsible for the creation of curriculum materials (teacher educators, curriculum developers and resource center teachers) have limited but regular access to computers. Further, many of these individuals have demonstrated their interest in exploring the potentials of computer supported curriculum development (Madzima, 1999 and Van de Put, 1999). (For additional information regarding the education system in Zimbabwe, please refer to Gatawa, 1995).

1.4 Aim of the study

The primary aim of this study was to explore the potential of computer-supported curriculum development as a viable solution to some of the teacher development and curriculum development challenges faced by southern African science and mathematics educators. As previously mentioned, various reform efforts in the southern African region are on-going, especially in the arena of science and mathematics education. Many of these programs are based on the notion that teacher development is directly linked to curriculum development. Due to policy decisions that necessitate production of new or more appropriate lesson materials, many educational improvement programs choose this as an area of concentration. They do this because the process of engaging teachers in materials development is considered to be a viable, effective and practical form of professional development (Ball & Cohen, 1996; De Feiter, Vonk & van den Akker, 1995; Ben-Peretz, 1990). Simultaneously, this fulfills the needs in the curriculum development arena for new materials. This study explored ways of using ICT to help reinforce and intensify the synergism that exists between teacher development and curriculum development. Toward that goal, the CASCADE-SEA program was designed, developed, evaluated and revised. This took place in cooperation with various curriculum development programs, most of which were located in South Africa, Tanzania and Zimbabwe.

1.5 Research approach and intended outcomes

The rationale behind this study is consistent with that of educational research in general: by working toward a better understanding of certain processes, it is hoped that steps will be made toward improvements. In this case, the notions of curriculum development, teacher development and their crossroads, materials development, were the topics of inquiry. Throughout this research, the primary focus remained targeted on the rather concrete issue of designing and developing an EPSS that would be appropriate for the aforementioned goal of supporting materials developers. Therefore, the study focused on learning more about the characteristics of such a support system. In order to accomplish this, the successive development, evaluation and redesign of the CASCADE-SEA program took place in cooperation with user and expert groups, most of whom were involved with southern African science and mathematics education. This expedition-like process was selected because it seemed the most promising in terms of being able to yield the kind of information researchers sought. The reasoning behind prototype (re)design decisions was carefully documented. The net result has been the generation of design principles regarding both the processes (of development research) and the product (the system itself).

1.6 Overview of the following chapters

As this chapter has illustrated, the CASCADE-SEA study was born out of the convergence of three main trends: the international growth of ICT (in particular, the field of EPSS), the University of Twente's commitment to inquiry regarding computer supported curriculum development and an increased cooperation with science and mathematics educational improvement initiatives in southern Africa. The subsequent chapters in this book describe the activities undertaken and resulting outcomes as part of this study. Toward a deeper understanding of the ideas behind this research, *Chapter 2* examines the arenas of curriculum development, teacher professional development and EPSS. In the beginning of the chapter, a survey of international literature on these themes is presented, while the latter portion of the chapter features discussion of how to engage teachers in the process of materials development - with the support of the computer - in the context of southern Africa. Having a clearer understanding of the intentions of the study and related implications from existing research, *Chapter 3* describes the research design. This includes discussion of development research, the role of prototyping and the structure of the research in terms of planning, respondents, sampling, data collection and analysis. *Chapter 4* describes the evolution of the CASCADE-SEA program. After a brief look at the main phases of development, the bulk of this chapter focuses on a description of the final product, which consists of a CD-ROM and an Internet component. The road leading up to this final version is then redrawn in *Chapter 5*, which looks closely at the research results from the initial analysis phase, the design and development phase and the final evaluation. *Chapter 6* centers around discussion of the findings, reflections on the study as a whole, and conclusions that can be drawn with regard to the main research questions. This book closes with recommendations for future endeavors with regard to products (support tools) and processes (through which research and development takes place).

Chapter 2

Creating the synergy between curriculum development and teacher professional development

The previous chapter described the origins of this study, including brief portraits of the context in which the research was conceived as well as the setting where it took place. Building on that, this chapter examines the theoretical motives for carrying out this exploration. Against the backdrop of science education in southern Africa, the concepts of curriculum development, teacher professional development and computer-based performance support are discussed here. In addition to treatment of related empirical research findings, this chapter looks at the interplay between these concepts and the resulting yield in terms of implications for the research. It should be noted that many of the ideas presented in this chapter matured throughout the study. In that sense, some of the same concepts that provided the impetus for further exploration were, themselves, the object of examination. The following pages illustrate the conceptual framework that has grown as a result of this research.

2.1 Toward a conceptual framework

The discussion within this chapter centers around the core ideas behind this study. Such ideas relate to the areas of curriculum development, teacher professional development and computer-based performance support. To facilitate explanation of how these themes relate to the research, a conceptual model is presented on the next page (Figure 2.1). In it, one can see that the arenas of curriculum development and teacher professional development overlap in the process of creating exemplary lesson materials. Further, the notion of computer-based performance support, tailored and offered to enhance that process, is also represented. The final element in the model is the support structure in which these activities take place. This study targeted regional teacher resource centers, although teacher training colleges and universities also served as support structures on occasion.

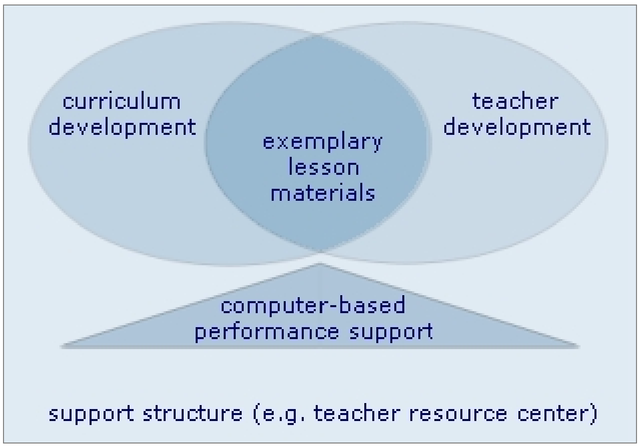

Figure 2.1: Conceptual model used throughout this study

It should be noted that, in this model, the term, 'support structure' does not only refer to physical infrastructure. This concept also includes the larger framework or program (for example, a teacher in-service program) that provides the foundation for such physical and social facilities as teacher resource centers, teacher training colleges or university faculties.

This model was used to help focus the research. With the main goal of exploring the computer's potential supportive role during the creation of exemplary lesson materials in the domain of science education in southern Africa, a literature study was conducted to learn more about curriculum development, teacher professional development, materials creation, computer-based performance support and support structures in which these activities take place. Guidance was sought by turning to existing knowledge for answers to the following questions:

- What is curriculum development?
- What are important aspects of teacher professional development?
- How does preservice and inservice education relate to curriculum development?
- What is the role of exemplary materials within curriculum development and teacher professional development?
- What kinds of support structures exist for curriculum development and teacher development relating to science education in southern Africa?
- How might the computer contribute to existing activities in the area of materials development?

Throughout the attempt to synthesize research findings relating to these questions, the target context remained a central consideration. As a result, wherever possible, information on each of the above-mentioned themes was examined in general, and in terms of how it relates to secondary level science and mathematics education in southern Africa. The remainder of this chapter presents the findings of the literature survey, and describes how this information influenced the study. The discussion begins with an examination of the curriculum concept and how curriculum is made. Thereafter, the concept of teacher professional development is highlighted, with particular attention being given to the two main sorts: preservice and inservice education. Because the creation of classroom materials is frequently found to be a viable form of professional development, the subsequent section focuses on the role of exemplary materials in curriculum development and teacher development. In looking at the circumstances under which exemplary materials are created, support structures - particularly teacher resource centers (TRCs) - are discussed. Finally, the topic of computer-based performance support comes into play as a way to support the materials development processes taking place at teacher resource centers. This chapter concludes by describing the implications for the study that were derived from literature. Particular attention is given to design considerations (regarding a computer-based tool for materials development in the given context) and to research considerations (regarding the approach used).

2.2 Curriculum development

2.2.1 What is curriculum?

As a field of study, "it is tantalizingly difficult" to know what curriculum is, (Goodlad 1994, p. 1266). Although Taba's (1962) definition of a 'plan for learning' is generally accepted, dispute abounds with regard to further elaboration of the term (Marsh & Willis, 1995). Within this study, the notion of curriculum has been treated from an inclusive perspective. That is, the broad definition of a plan for learning has been used as a starting point, while additional perspectives have been sought to enhance understanding of this notion. The remainder of this section presents those perspectives that have been most influential in structuring this research.

Curriculum is a complex, and multi-dimensional concept that relates to various levels of the educational system, exists in numerous representations, holds varying degrees of versatility, may be viewed from multiple perspectives and is composed of myriad elements. Curriculum may focus on the macro level (nation or region), the meso level (school, institute) or the micro level (learning setting). Similarly, the ideas bound together in a curriculum may be manifested through various representations. Goodlad, Klein and Tye (1979) distinguish a range of representations, adapted by Van den Akker (1988, 1990), which illustrates curriculum evolution. This typology begins with designers' intentions (ideal curriculum), then proceeds to their written form (formal curriculum), moves on to the interpretations made by its users (perceived curriculum) as well as the way it is actualized in the learning setting (operational curriculum) and concludes with the way it is experienced by the pupils (experienced curriculum) plus, ultimately, learner achievement (attained curriculum).

Further, degrees of versatility come into consideration as an important dimension of curriculum. Whether a curriculum is being created for generic use (intended for many settings) or site-specific application (intended for a particular setting) can significantly influence its design (cf. Walker, 1990). Curriculum may also be influenced from different perspectives; Goodlad (1994) defines three: socio-political, technical-professional and substantive. The socio-political perspective refers to the influence exercised by various stakeholders (pupils, parents, teachers, administrators, curriculum developers, etc.). The technical-professional perspective is concerned with methods of the development process itself (including engineering, logistics and evaluation) whereas the substantive perspective includes the 'commonplaces' of the curriculum such goals, subject matter and materials.

▪ Goals, objectives & purposes	▪ Teaching strategies
▪ Content	▪ Evaluation
▪ Materials and resources	▪ Grouping
▪ Activities	▪ Time
	▪ Space

Box 2.1: Essential elements of curriculum according to Klein (1991)

Klein (1991) describes nine 'essential elements' of curriculum, as represented in Box 2.1 (right). Goals, objectives and purposes reflect the anticipated or actual outcomes of teaching and learning. Content refers to those facts, ideas, concepts, processes, generalizations, attitudes, beliefs and skills with which students interact as they experience a curriculum. Materials and resources are the objects, places and people used to facilitate the learning process. What students do while they engage in the process of learning falls under the heading of activities. Teaching strategies are defined as the role taken by the instructor (be it a person, book, computer program etc.) in order to facilitate learning. Procedures for determining what students are learning or have learned are forms of evaluation. Grouping refers to the processes and results of determining the composition of clusters of pupils that facilitate the learning process. Whether allocated on a formal or informal basis, time is also a fundamental element of curriculum. Finally, space refers to the design and use of the physical learning environment, such as the classroom, school or shade of a tree.

In international literature, increasing attention is being given to considering the role of context in educational change (Hargreaves, 1998) and in particular, the socio-political perspective in the design of curriculum. Tessmer and Richey (1997) suggest methods for conducting a contextual analysis and utilizing its results for context-based instructional design which, they say, will make results systematic as well as systemic. Ogunniyi (1996) also underlines the importance of context in his article on science, technology and mathematics policy in southern Africa, stating that curriculum materials must be attuned to the socio-cultural setting of African children. Taking a broader perspective on the role of context in creating curriculum, Rogan (2000, p. 121) notes that, "Curricula are embedded with cultural values. For example, a curriculum designed in a Western country may place value on individual development, which if transplanted, may well be at odds with the African notion of 'ubuntu.'[3]" In countries where the driving forces behind curriculum innovation stem from local insights, contextual influences often remain 'hidden' or at least implicit. But in settings where innovations are frequently adopted from outside (as has been the case with many southern African countries in the last two decades), the potential for clashing values is often underestimated. Many experts argue that the dominance of Western curricula in African countries has stemmed from colonial legacies (Blum, 1979; Hawes, 1979; Lillis, 1986; Selvaratnam, 1988; Yoloye, 1985). In an attempt to better understand such arguments, it may be useful to consider how curriculum is created.

2.2.2 How is curriculum made?

As previously stated, curriculum dimensions include various levels, representations, degrees of versatility, perspectives and elements, many (or all) of which may be shaped by context. The decision making process regarding each of these dimensions is seen to be essential to the notion of curriculum development. Like the notion of curriculum itself, this process is multi-faceted and complex. As Eisner (1994, p. 371) puts it, "The process of curriculum development, like the process of doing quantitative empirical research, appears much neater and much more predictable in textbook versions of curriculum development than it is in practice." For further information on the complexities of development strategies in practice, please refer to Walker (1971) or Van den Akker, Boersma and Nies (1990). Yet many will agree that, despite (or because of) the complexities, conceptual models can serve as referential systems for planning, (Hameyer, 1994).

Curriculum planning models

In the domain of curriculum development, such models abound. Posner (1994) distinguishes between various types of curriculum planning models by examining those that are more procedural (consisting of steps to follow), descriptive (explaining what to do) and conceptual (detailing elements and relationships of main ideas). Another distinction is made by Gustafson and Branch (1997), who provide a taxonomy for examining design and development models based on what curricular product is being created. Further, models also vary in terms of their implicit assumptions about the nature of the curriculum development process. They may be linear (Tyler,

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[3] According to Wolmarans (1995), "Ubuntu is the main pillar of traditional African values which bonded people together in difficult times. It centres around love, gentleness, sharing and caring for each other. 'Humaneness' or being human 'in relation to other human beings' is synonymous with ubuntu."

1949; Taba, 1962; Romiszowski, 1981), they may integrate loops of feedback (Plomp, 1982; Dick & Carey,1996), or they may be expressly based on a cyclic, iterative approach (Nieveen, 1997; Keursten, 1994; Ottevanger, 2001). Still other models are particularly organic in nature, focusing more on the core ideas of an innovation (Posner & Rudnitsky, 1986; Walker, 1990), taking individual designer preferences into account (Eisner, 1979; Schön, 1983) or explicitly featuring the influence of context on the design process, (Tessmer & Wedman,1990; Tessmer & Richey, 1997). For an overview of curriculum planning models, please refer to Marsh and Willis (1995); for detailed discussion of the influence of designer beliefs on the curriculum development process, please refer to Visscher-Voerman (1999).

Throughout this study, careful examination of curriculum planning models has taken place to gain insights into how to structure this research in general, and more specifically, how to create a support system for curriculum development in the given context. Chapter 4 contains a more detailed discussion of how these models influenced the design of the CASCADE-SEA program. Yet curriculum planning models are not the only influence on curriculum development. The following sections examine contextual determinants of curriculum and international trends in curriculum development, respectively.

Curriculum and context

Determinant	Includes
Historical context	▪ Traditional education ▪ Mission education ▪ Colonial education
Socio-political context	▪ Cultural factors ▪ Politics ▪ Societal factors
Economic context	▪ Educational expenditures
Administrative context	▪ Bureaucratic structure ▪ Centralized policy-making ▪ School types
Participants in curriculum development	▪ Internal participants ▪ External participants

Box 2.2: Determinants of curriculum as defined by Thijs (1995)

As previously mentioned, context plays a significant role in shaping the curriculum. Thijs (1995) distinguishes five contextual factors that exert influence on curriculum development in Africa. These curriculum determinants are summarized in Box 2.2 (left).

As this list illustrates, comprehension of the process of curriculum development in southern Africa is directly linked to an understanding of certain contextual factors. Additional descriptions of how these factors pertain to the countries involved in this research (Botswana, Lesotho, Namibia, South Africa, Swaziland, Tanzania and Zimbabwe) may be found in Chapter 3, which describes the cycles of formative evaluation that took place during development of the CASCADE-SEA program. General descriptions of these factors relating to the countries most heavily involved in this study (South Africa, Tanzania and Zimbabwe) were given in Chapter 1.

International trends in curriculum development

Curriculum development, particularly the area of science education, has undergone waves of renewal in the past few decades. As mentioned in Chapter 1, a major reform period began following the launch of Sputnik. This continued on until the 1970s (in some cases, even longer), and was earmarked by innovations taking place on a large scale. Despite concerted efforts, many improvement projects were considered failures. Perhaps in part due to disappointing results in the past, the 1980s saw a shift to debates on accountability and the most appropriate forms of curricular reform. These debates were fueled by changing societal concerns as well as new scientific insights. The 1990s have born witness to a rebirth of large-scale reform, tempered by cautions resulting from failed efforts in the past. In this most recent wave of reform, systemic, sustainable change receives the main focus. A core element of this focus is the careful consideration of new (and/or improved) implementation strategies. For an overview of science curriculum development, please refer to Van den Akker (1998); for additional information regarding the return of large-scale reform, please see Fullan (2000).

Throughout the first two waves of curriculum reform, most study of curriculum implementation took place from a fidelity perspective. That is, researchers focused on measuring the degree to which a particular innovation was implemented as planned, and on identifying the factors that facilitated or hindered implementation as planned (Snyder, Bolin & Zumwalt, 1992). The magnified focus on curriculum implementation has emphasized the perspectives of mutual adaptation and - in more recent years - enactment. Mutual adaptation suggests that curriculum implementation is a process whereby adjustments in a curriculum are made by curriculum developers and those who actually use it in a school or classroom context. Curriculum enactment, on the other hand, views curriculum as the educational experience jointly created by the student and teacher. From this perspective, the role of the teacher is that of a curriculum developer who, according to Snyder, Bolin and Zumwalt (1992, p. 418), "grows ever more competent in constructing positive educational experiences." A teacher's ability to construct such experiences is certainly related to (the quality of) externally created curricular materials and instructional strategies. Yet, one's own level of professionalism is likely to yield an even stronger influence on this process. Toward a better understanding of the relationship between teacher professionalism and curriculum enactment, teacher professional development is addressed in the following section.

2.3 Teacher professional development

Within this research, the term 'teacher professional development' is used to discuss the professional growth that takes place throughout a teacher's career. This notion is then broken down into two main categories: preservice (certification and initial teacher education) and inservice (referring to the further education of a practicing teacher). The latter term, inservice, is sometimes used synonymously with others such as INSET, teacher development or staff development.

Teacher professional development is considered important for a host of reasons (cf. Eraut, 1994), ranging from improving pupil achievement (Van Blanken, 1995) to broadening the teaching repertoire (Hopkins, 1998). Continued professional growth of teachers is widely accepted as an essential ingredient to any educational reform (Black & Atkin, 1996; Fullan, 1991; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Yager, 1994; Van den Akker, 1996). Such ideas form the backbone of this study, in which curriculum development and teacher development are seen to strengthen one another. In order to explore ways of fostering the synergism that should exist between these two processes, it may be useful to examine each more closely. Having addressed the topic of curriculum in the last section, the following text discusses the two main forms of teacher professional development: inservice and preservice education, as well as their links with curriculum development. Although preservice teachers were not part of the original target population within this study, this group did eventually become involved due to repeated participant requests. For this reason, preservice education is discussed in brief, while more attention is given to inservice education.

2.3.1 Preservice education

While the design of preservice education differs greatly from one country to the next, most programs share some common curricular features. According to Ben-Peretz (1994), teacher education is generally based on four components:

- subject matter studies
- foundation of education studies
- professional studies (such as method courses)
- practicum (supervised practice)

Similarly, Borko and Putnam (1996) organize their thinking about learning to teach around three main concepts: general pedagogical knowledge, subject matter knowledge and beliefs, and pedagogical content knowledge and beliefs.

In these examples, as in others (Borko, Michalec, Timmons & Siddle, 1997; Gimmestad & Hall, 1994), fostering skills in the arena of curriculum development forms a key ingredient in a preservice program. Usually this is most evident through professional studies or pedagogical courses that prepare teachers to plan lessons and to create their own lesson materials. While some programs place relatively little emphasis on these skills (frequently choosing to devote more time to learning subject matter content), some experts would like to see these courses given additional weight. For example, Johnston (1995, p. 692) states, "There is a convincing case made for beginning teachers to understand their role in curriculum, to be able to use various curriculum approaches to planning effectively and critically as well as developing their own vision of what it means to be a professional teacher involved in curricular decisions."

Such ideas are resonant in a relatively recent movement in preservice education research, aiming toward learning more about what novice teachers need to know and learn about curriculum and curricular materials. One study that examines this area (specifically, curriculum planning) was carried out on the use of portfolios. Borko et al. (1997) included 'planning entry' (information about planning and teaching that addresses both instructional units and specific teaching episodes) as a main element in their study on the use of portfolios in student teaching. They claim that their research provides empirical support for the numerous theoretical claims regarding the value of portfolios as tools for promoting reflection. The notion of reflection, and constructing meaning for oneself, as a valuable contributor to preservice educational development, is also shared by others (cf. Yager, 1994). One common way to combine practice, reflection and the construction of meaning is to engage student teachers in the cycle of planning of lessons, trying them out and reflecting on what happened.

While such a cycle may be explicitly planned within a teacher education program, or may happen naturally of its own accord, it is an integral part of the process of learning to teach. Preparing lessons (and accompanying materials), carrying out those plans and reflecting on what transpired yields insights that contribute to the professional growth of the individual, particularly in the arena of curriculum development. This naturally occurring cycle is (to varying degrees) part of nearly every teaching career, and the opportunities for professional development are not limited to beginners. Gimmestad and Hall (1994) discuss the need to provide training, support and education for teachers (especially recent graduates) and call for a continuum of shared involvement between higher education and the schools. The next section examines the continuing (inservice) education of practicing teachers, with particular attention to its link with curriculum development.

2.3.2 Inservice education

As in many areas of study, various authors choose to highlight differing elements in their definition(s) of the field. Guskey (1986, 2000) focuses his definition of staff development on the notion of changing teacher beliefs and attitudes. In slight contrast, Glatthorn's (1994) definition of teacher development takes a broader perspective, looking more generally at learning and growing through practice and systematic reflection. However, Heideman, (1990) says that *inservice education* is almost exclusively informational in nature, and states that *staff development* goes beyond that, being concerned with personal as well as professional and organizational needs. In a similar vein, Collins and Spiegel (1998) make a distinction between *professional development* and *teacher enhancement*. Finally, Fullan's definition (1990, p. 22) might be the broadest in scope as he says that staff development is the "…sum total of formal and informal learning experiences accumulated across one's career." He goes on to emphasize the importance of the spirit and practice of life-long learning for all teachers. Such a perspective also has implications for the way staff development should be approached. For additional perspectives on career-long professional development of teachers, please refer to Kwakman (1999).

After briefly reviewing the variation in definitions of what inservice is, one might conclude, quite logically, that similar variation also exists in terms of how inservice should be structured. Eraut (1994), summarizes the various approaches to inservice education in his discussion of four categories:

- INSET for unqualified teachers (mainly certification courses);
- INSET to upgrade teachers;
- INSET to prepare for new roles, such as principal or teacher educator;
- curriculum-related INSET (mainly courses linked to planned curriculum change or ad hoc refresher courses).

Some models for structuring inservice education are geared primarily toward one of these areas (cf. Guskey, 1986), while others are more generic in the sense that they are usable for any or all of these categories (cf. Heideman, 1990; Joyce & Showers, 1988). While this study was influenced by numerous perspectives on teacher professional development, the approach used is best captured in the description given by Loucks-Horsley et al. (1998). They identify seven principles that should be addressed in effective professional development experiences; these are summarized below.

Effective professional development experiences:

- are driven by a well-defined image of effective classroom learning and teaching;
- provide opportunities for teachers to build their knowledge and skills;
- use or model with teachers the strategies they will use with their students;
- build a learning community;

- support teachers to serve in leadership roles;
- provide links to other parts of the educational system;
- are continuously assessing themselves and making improvements to insure positive impact on teacher effectiveness, student learning, leadership, and the school community.

Decisions relating to each of these seven areas were weighed during the design and development of the CASCADE-SEA program. Similarly, because this study was conducted via naturally-occuring testbeds (as opposed to artificial settings), these principles influenced the design of data collection activities, as well. For more detailed discussion of how development and research methods were impacted, please refer to Chapter 3.

In addition to the structure of a teacher development program, many other factors are likely to influence (the enacted curriculum of) teacher development. In particular, Glatthorn (1994) discusses the role of personal factors and contextual factors, in addition to the characteristics of a specific intervention. The idea that context plays a significant role in shaping inservice education is also shared by many experts in the field (Eraut, 1994; Fullan, 1991; Loucks-Horsley et al., 1986; Loucks-Horsley et al., 1998). One contextual factor that has played a pivotal role within this study relates to the notion of collaboration, in particular, the perceived roles of participants in inservice education.

In his article calling for South African teachers to be setting the inservice agenda, Gray (1999, pp. 265-266) notes, "If any degree of professionalism is to emerge, then the responsibility for ongoing professional development of teachers needs to be shifted fairly and squarely onto the shoulders of teachers themselves, with the authorities and outside agencies playing a secondary, supportive role. Teachers need to own and drive the process and to make decisions about what is to be done." Similarly, Lally, Knutton, Windale, and Henderson (1992) present a model that features a 'negotiated needs agenda' which, they claim, does lead to effective and sustainable change in classroom practice. It involves taking the values and contexts of individual teachers in their own classrooms, with their own pupils as a starting point for inservice education. Borko et al. (1997) refer to Richardson’s (1992) 'agenda-setting dilemma' where the staff-developer wants to see teachers’ practices change in a particular direction while still respecting the teachers’ craft knowledge and empowering them to make changes. They look at the importance of setting the agenda collaboratively, and recommend taking advantage of the expertise that both university-based researchers and experienced teachers can offer.

In line with the views mentioned above, a basic tenet upon which much of this research has been built, is the notion that inservice education must be driven by the collaboration of those parties involved. In particular, this implies a shared vision between those for whom the inservice is intended (teachers) and those who facilitate its existence (inservice education providers). Similarly, the notion of collaboration as a tool to help realize much of the positive potential that staff development has to offer is also reflected by those who conduct research. Clandinin and Connelly (1992) make a plea for collaboration between researchers and practitioners, particularly in terms of studying the role of the teacher as a curriculum maker in inservice education. And they are not alone; others (Eisenhart & Borko, 1991; Lieberman, 1986; Noddings, 1986; Zumwalt, 1988) also call for collaborative relationships toward understanding how the curriculum is shaped by the teacher. Even though much remains to be learned about the relationship between teacher development and curriculum, lessons from the existing body of knowledge in this area may be used as a springboard to inform future efforts, as described in the following section.

The involvement of teachers in curriculum development has been widely advocated as an effective form of inservice education (Ball & Cohen, 1996; De Feiter, Vonk & Van den Akker, 1995; Dlamini, Putsoa, Campbell, & Lubben, 1996; Ben-Peretz, 1990). Gray (1998) notes specific benefits of such an approach used within the context of secondary level science education in southern Africa. He observes that teachers attributed their ongoing involvement in a particular curriculum development project to several overlapping factors: the opportunity to interact with other teachers, their positive experiences of the curriculum development process itself, and the perceived benefits to their professional development. He elaborates on the latter aspect of professional development to include the following areas in which impact was felt:

- the development of critical skills with respect to curriculum development;
- development of writing skills;
- greater confidence in subject-matter knowledge;
- improved access to teaching resources;
- greater professional confidence and morale-boosting;
- the benefits of secondment (time away from school and learning about administration);
- impact on teachers' conceptions of teaching and their classroom practice.

Gray indicates that time played a vital role in the professional development process, saying that when teachers were able to become immersed in such activities, this ‘time to think’ yielded marked results. Such immersion can be achieved in two main ways: teachers may take (or be given) time away from normal teaching duties, or opportunities for professional development may be coupled with teaching practice.

Putnam and Borko (2000) also give attention to the importance of situated learning opportunities in terms of teacher development and curriculum development. They identify a common problem, saying that both novice and experienced teachers often complain that learning experiences outside the classroom are too removed from the day-to-day work of teaching to have a meaningful impact. They identify (specific advantages of) certain beneficial contexts within which teachers' learning might be meaningfully situated: their own classrooms, group settings where participants' teaching is the focus of discussion, and settings emphasizing teachers' learning of subject matter. Within each of these contexts, the creation of curriculum materials can play an important role. In such a case, the connection to everyday practice is clear while at the same time, the opportunities for learning are numerous. As Jonassen and Reeves (1996, p.695) put it, "…the people who seem to learn the most from the systematic instructional design of instructional materials are the designers themselves." Similar ideas have been echoed by other instructional designers (Paquette, Aubin & Crevier, 1994) as well as experts in the area of curriculum change in developing countries, (Montero-Sieburth, 1992). Effectively harnessing the powerful potential that exemplary materials have to offer to both curriculum development and teacher professional development has been one of the challenges undertaken within this study. The following section reflects on the ideas derived from literature that contributed to addressing this challenge.

2.4 Exemplary materials

There is no doubt that curriculum change is a difficult, complex process. In fact, many studies of attempts at innovation have reported the lack of sustained impact on classroom practice. However, De Feiter et al. (1998) report on curriculum development studies in southern Africa wherein successful implementation can be accomplished through the provision for intensive support scenarios. They recommend employing the following strategies: use of well-tried exemplary materials, ample opportunity for teachers to practice innovations and the creation of a supportive school environment. The remainder of this section focuses on the first element, and looks at why exemplary materials are important. Then, with this in mind, consideration is given to how such materials may be optimized and created.

2.4.1 How can they help?

Against the backdrop of curriculum innovation, the role of lesson materials, especially those that illustrate desired practice (exemplary materials), is significant. Heyneman (1978) reviewed internationally published evidence on the relationship between curriculum materials and student performance and found that the availability of (text)books is a consistently good predictor for academic achievement. In developing countries, teachers not only lack textbooks but also supplementary materials (Baine & Mwamwenda, 1994).

This is due to the fact that, even with low salaries, almost all of the school budgets in developing countries are spent on personnel, which leaves little for textbooks and other instructional materials (Van Blanken, 1995). Because the problem of fund allocation has it roots in national-level economic issues that are not likely to be solved easily or quickly, solutions are often sought elsewhere. One such approach to this problem is the local creation of low-cost materials, such as paper-based teacher guides that supplement textbooks.

Lockheed and Levin (1993) found that, in developing countries, teacher guides that are well integrated with the textbook or other instructional materials can have a positive impact on student achievement. In line with this notion is the call for aid organizations to play roles in the development of locally-relevant classroom materials - a plea which is echoed by many experts in the field (Clegg & Osaki, 1998; Hawes, Coombe & Lillis, 1986; Lockheed & Levin, 1993; Williams, 1986). Such recommendations are likely to stem from the broad base of implementation research that has illustrated how effective teacher guides can be in supporting curriculum implementation.

Particularly within the last fifteen years, the role of exemplary materials in supporting curriculum change has been researched across the globe. In general, exemplary materials have been found to be especially useful during the initial phases of curriculum implementation. Van den Akker (1998) summarizes three main advantages offered by exemplary materials:

- clearer understanding of how to translate curriculum ideas into classroom practice;
- concrete foothold for execution of lessons that resemble the original intentions of the designers;
- stimulation of reflection on one's own role with the eventual possibility of adjusting one's own attitude toward the innovation.

While similar benefits of the role of materials have been identified by many other researchers (Ball & Cohen, 1996; Van den Berg, 1996; Roes, 1997; Thijs, 1999), most of these experts also agree that offering lesson materials alone yields limited results. Instead, they recommend a combination of exemplary lesson materials along with additional forms of teacher support, such as inservice education (De Feiter, Vonk & Van den Akker, 1995; Ottevanger 1998; Van den Akker, 1998). In some cases, materials are introduced to teachers during inservice activities; they may even serve as a form of follow-up after workshops, providing longer-lasting support as teachers may take materials away with them. But sometimes the strength of exemplary lesson materials is tapped into from another angle. Rather than merely presenting materials to teachers as illustrations of curriculum innovation, some inservice programs foster deeper levels of understanding by helping teachers to create exemplary lesson materials themselves.

In one such innovation, Gray (1998) reports that teachers created, revised and distributed lesson materials. His study found that this process represented a significant change in practice and approach, and that teachers relied heavily on the materials to do so. Other authors look even more closely at the benefits of teachers creating curriculum materials. Ben-Peretz (1990) advocates teacher participation in curriculum development because of the opportunities it provides for experiencing decision-making with regard to content, instructional strategies, scope and sequence. McKenney (1995) found that the learnings gleaned from creating as well as using good quality materials can serve to bolster confidence in teaching and, as a result, improve overall classroom performance. Still others have found that products developed by practicing teachers have more credibility to other teachers as being something that is truly usable in the classroom (Doyle & Ponder, 1978; Viggiano & Dixon, 1998)

So involving teachers in the development of curriculum materials can yield benefits in two main areas. Materials designed by fellow teachers may be seen to be more credible than those created by so-called experts. And for those who are designing the materials, learning takes place through reflection on good practice and making those ideas explicit in a form that is usable by others. Materials development activities that are embedded in inservice programs often facilitate discussion and collaboration between teachers, as such activities tend to take place within small design teams. Through this approach, many of the aforementioned criteria for effective inservice (Loucks-Horsley et al., 1998) may be achieved. It helps teachers to begin translating abstract ideas into more clearly-defined images of effective classroom learning and teaching while also providing opportunities for teachers to build their knowledge and skills. It offers teachers an opportunity to experience group work and collaboration, thus modeling the strategies teachers will use with their students. By working together with colleagues, a learning community may be established, and because such activities connect teachers from various schools, inservice providers and, in some case governmental organizations (national curriculum development units, for example), links are provided to other parts of the educational system.

2.4.2 Characteristics of materials

Having examined the potential benefits of using and making exemplary lesson materials, an important question then arises: what kind(s) of materials are most useful? Bearing in mind the hope of being able to maximize the (aforementioned) potential benefits of such materials, an effort should then be made to create materials that (1) provide a clear understanding of core curricular aspects, (2) offer concrete examples of how this translates into practice and (3) stimulate reflection by the user. Research has shown that teacher support materials including step-by step guidelines - or procedural specifications - can speak to these three issues (Brophy & Alleman, 1991; Clegg & Osaki, 1998; De Feiter, Vonk & Van den Akker, 1995; Ottevanger, 2001; Thijs, 1999; Van den Akker, 1988).

Additional supporting arguments for the inclusion of specific information on how to proceed as a constituent element in lesson materials (teacher guides) are offered by Hameyer and Loucks-Horsley (1989). They argue that the success of innovative efforts depends considerably on the quality and demandingness of the materials. Especially when curriculum change is on the agenda, they recommend the following (p. 14):

> *Any new product, according to recent research, should be sufficiently flexible for varied use, applicable to different schemes of teaching, its fundamental aims clearly exposed and the conditions under which it works clearly specified. These features do not diminish the necessity of making the indispensable core components explicit, so to speak the heart of the new. Developing exemplary materials is one way to show how the innovation might work. As long as a new idea is explained only in the shape of a general scheme, it remains insufficient for further application. The more complex an innovation is, the more necessary is its specificity in terms of materials or other products so that the users can understand the new. The central point here is the level of specificity.*

Van den Akker (1988) identifies four areas of implementation problems within the domain of science education, as well as guidelines for how to address these areas through exemplary materials. He recommends procedural specifications that focus on helping teachers cope with lesson preparation, a lack of knowledge and confidence in subject matter content, changing roles of pupil and teacher and assessing learning effects. In the case of exemplary materials for science and mathematics education in southern Africa, Clegg and Osaki (1998) also recommend that teacher guides include lesson plans with diagnostic tests to assist teachers in monitoring student learning and in modifying the daily lessons accordingly, as well as suggestions on classroom management practices and activities for classroom use.

It should be emphasized that procedural specifications are meant to offer supportive guidelines, not exact formulas, for curriculum enactment. Unless teachers identify their needs as otherwise, such materials should not be treated as prescriptive. Many judgements can and should be made during implementation (cf. Snyder et al.). The users of materials are ultimately in control of how they will be implemented in the curriculum, (Clandinin & Connelly, 1992; Ben-Peretz, 1994, Fullan, in print). Bearing in mind that the teachers themselves will act as curriculum-makers, selecting the elements they find worthy of use, the main function of (exemplary) lesson materials is therefore to give examples of how teaching practice could take shape.

2.4.3 Supportive environments

The notion of engaging teachers in the process of creating exemplary lesson materials (featuring procedural specifications) is not new to science education in southern Africa (De Feiter, et al. 1995; Gray, 1999; Ottevanger, 2001). Several African countries combine full-time provision of inservice education with part-time correspondence courses supplemented by visits and residential summer schools (Eraut, 1994), as is the case with some of the projects associated with this study. In order to realize this, inservice providers are necessary. According to Dove (1986, p. 262), the training of trainers (educators) has become a top priority in developing countries. Toward this end, she recommends that "teacher trainers themselves should be very much involved in the planning and designing of the curriculum." With this in mind, one can conclude that the creation of exemplary lesson materials is not only a valuable activity for teachers in general, but especially for those teachers who facilitate inservice education.

In addition to looking at who (which groups of teachers) can benefit most from making exemplary materials, it is also necessary to consider settings in which such activities have a good 'fit.' As previously mentioned, the creation of exemplary materials can offer more when embedded in inservice education. Toward this end, Gray (1999) recommends the use of 'cooperative structures' that are managed and directed by teacher leaders, to support teachers. Fullan (2000) also advocates deployment of such structures, saying that they are able to offer balanced interaction between pressure and support - an especially useful combination for large-scale development and reform. One form of such support structures is that of teacher resource centers, which is discussed in the following section.

2.5 Support structures and TRCs

As explained earlier in this chapter, the notion of support structures should not be confused with physical infrastructure. More specifically, this term refers to a framework or program such as teacher preservice or inservice education. However, the nature of physical facitities within such support structures can often have a strong influence on the program offered by a teacher resource center (TRC), teacher training college or university faculty. In looking at ways to support the creation of exemplary materials within the given context, connections with various kinds of support structures were explored. In early stages of the research, the decision was made to target support toward inservice (exemplary materials development) activities taking place with (facilitator) teachers at regional TRCs. This decision was based on an analysis of the context (see Chapter 5 for additional detail) and on insights from literature. Teacher training colleges and universities later served as support structures as well within this research, but because TRCs were the primary focus, they receive the bulk of emphasis in this discussion.

Reasons for the evolution of TRCs are numerous and undoubtedly vary somewhat from country to country. However, according to Howey (1986, p. 74), it is quite apparent that in many situations, "a dominant catalyst for the evolution of the centers is a growing desire on the part of the teachers to have the preeminent voice in matters of their own continuing development." This idea is illustrated by Ali et al. (1993) who, in describing the main principle behind the establishment and growth of a TRC in Pakistan, state that their work was guided by the notion that teachers' expertise is worth sharing and that this sharing leads to professional growth of both the giver and the recipient. In Africa, Ogunniyi (1996) attributes the success of certain science, technology and mathematics curriculum innovations (in part) to the creation of TRCs which have become fully or partially indigenized.

While there are often parallel rationales behind the establishment of teacher resource centers, different approaches to their development and ideas about what the centers can/should do have led to wide variation in terms of ownership and control, the scope and approach to activities and in the functions they have regarding teacher support. Howey (1986) notes that teacher centers are often distinguished by their degree of teacher-centeredness. TRC visitors and staff are not only involved in the identification of needs and interests but are also highly involved in the planning and conduct of inservice as well. Howey says that TRCs are commonly characterized by their informality and frequently emphasize learning through practical or hands-on activities. Finally, it is noted that teacher resource centers often provide attention and support for social as well as academic needs. For additional information including a typology of teacher resources centers, please refer to Howey, 1986; for more detailed descriptions of teacher centers in southern Africa, please refer to Hoppers, 1998; for reasons and examples of teacher center success or failure, please refer to Clegg and Osaki, 1998.

It should be noted that, while the idea of teacher resource centers has been around for a long time, their role in educational development has recently begun to become more prominent. Verspoor (1992) looks at changes in the planning of education in developing countries, and says that international assistance agencies are beginning to shift toward indirect intervention strategies, and then lists some examples of strategies that are much closer to school level (as opposed to centrally-based). Teacher resource centers are often seen as an effective bridge between central and local efforts. To further illustrate the trend, Hoppers (1998, p. 229) writes that "during the last two decades the concept of teacher resource centers (TRCs) has become widely accepted across southern Africa as an essential ingredient of a professional support structure for teachers and schools." For example, in discussing a model for teacher participation in curriculum development, Punch and Bayona (1990) call for the expansion of Tanzania's materials and advisory support services. To achieve this, they point to the necessity of investment in resources such as local and regional teachers' centers and curriculum development information centers.

In this study, supporting the curriculum development and professional development activities at such teacher centers remains central. Specifically, this research has focused on creating exemplary lesson materials in the form of teacher guides. One vehicle that holds significant potential for supporting the complex process of curriculum development is that of Information and Communications Technology (ICT). In fact, the combination of ICT tools and TRCs is perceived to be even more powerful in providing linkages between local and national resources. As many of the countries involved in this study are engaged in large-scale (national) curriculum reform, such linkages are desirable, if not entirely necessary. The following section describes the rationale for attempting to support the complex process of curriculum development through the aid of the computer, including explanation of why this combination (ICT and TRCs) was pursued.

2.6 Computer-based performance support

Interest in exploring the use of ICT to help foster teacher development has especially come into play in the last decade, particularly since the dawn of the Internet. Glatthorn (1994) presents three perspectives on fostering teacher development: standard approaches, alternative processes and the likely future of teacher development. Under the latter, he predicts an increase in the use of technology for delivering staff development programs. Since then, various studies have been conducted to explore how computers (especially multimedia and interactive software) can effectively contribute to teacher development in both pre and inservice settings (cf. Hatfield, 1996).

There are various ways in which ICT can be integrated into teacher development programs. Collis (1994) makes a distinction between technology in teacher education for two purposes: as a subject and as a delivery tool. With regard to the latter, she writes that there is a move away from the situation where a teacher education institution decides on an appropriate sequence and timing of inservice education toward a 'just in time' model based on teacher choice. "The distinction," she says, "between teacher education and ongoing professional support and development is rapidly blurring," (p. 6008). Many experts argue that computers can effectively contribute to teacher professional development by enhancing understanding of certain teaching/learning methodologies (Loucks-Horsley et al., 1998; Nicaise & Barnes, 1996; Risko, Peter, & McAllister, 1996). For example, Risko (1996) advocates the use of ICT toward establishing a 'community of thinkers' within a teaching methods course. Oftentimes, this is achieved through the presentation and analysis of classroom practice, through multimedia representations (cases). (For additional information regarding the use of multimedia cases in teacher professional development, please refer to Van den Berg & Visscher-Voerman, 2000.) But in other situations, ICT is used not to transmit images of reality, but to help create (parts of the) reality. Such tools support the design and development of (parts of) curriculum, as described in the following section.

2.6.1 Computer-supported curriculum development systems

Particularly within the last decade, many tools have been developed for the purpose of supporting the complex process of curriculum development (Grabinger, Jonassen, & Wilson, 1992; Gustafson & Reeves, 1990; Rosendaal & Schrijvers, 1990; Wilson & Jonassen, 1991; Zhongmin & Merril, 1991). For an overview of computer supported curriculum development systems (CSCDS), please refer to Nieveen, 1997. These tools may be examined from differing perspectives, based on varied criteria. Nieveen and Gustafson (1999) provide a framework for comparing and contrasting computer supported curriculum development systems, featuring five main sets of attributes: type of output, purpose, type of development process supported and any underlying theory, task support and intended user group. Toward a better understanding of the concept of computer supported curriculum development, this discussion is structured around the attributes mentioned above. For examples of computer supported curriculum development tools, please refer to Van den Akker, Branch, Gustafson, Nieveen and Plomp (1999).

CSCDS vary in terms of the type of output they help to produce. That is, the products resulting from use of the system may be aimed at various curriculum levels (micro, meso, macro). Further, these products can be intended for use by different groups (some systems help to make materials for learners while other systems assist professional curriculum developers in designing entire courses). Some systems produce outputs that are paper-based, while others are electronic, and some are a combination of both. Finally, some CSCDS are intended for a specific location with a specific user group in mind, while others are created for use by a wider (more generic) audience.

Another aspect in which CSCDS vary is their main purpose. Some tools are more geared toward supporting organizational learning, while others focus on the development of certain skills or the improvement of task performance. Further, the type of development process that is supported can vary from one system to the next. Some systems support initial phases of curriculum development such as analysis or design, while others focus more on implementation or evaluation; occasionally, CSCDS attempt to support the complete cycle of analysis, design, development, implementation and evaluation activities. Through the structure of this support, certain approaches to curriculum development may be seen (some are more prescriptive, others are more open-ended).

In a similar vein, systems vary in terms of the assumptions regarding those who will use them. That is, some are designed for use by professional curriculum developers, while others are for teachers and still others may be made for learners. Along with assumptions regarding the pre-entry curriculum development knowledge a user will possess, the (presumed) level of computer experience is also usually incorporated into the design of a system. Some CSCDS are designed with novice computer users in mind while others are created for the technically savvy.

Finally, systems offer their support in varying formats. Some CSCDS offer the flexibility to adapt the support offered (to tailor it to personal needs) while others remain more fixed in nature. The following section discusses characteristics of support offered within such systems. For additional information regarding the attributes within this framework, please refer to Nieveen and Gustafson (1999).

2.6.2 Characteristics of support

Much of contemporary thinking regarding the computer-based support of myriad task types stems from the field of Electronic Performance Support Systems (EPSS). According to Gery (1991, p. 24), the goal of EPSS is "to provide whatever is necessary to generate performance and learning *at the moment of need* …what distinguishes an EPSS from other types of systems or interactive resources is the degree to which it integrates *information, tools and methodology* for the user." Yet consensus has not been reached on the ideal balance of various elements in support systems. Raybould (1990) distinguishes three similar, but different components of EPSSs: an advisory system, an information base and learning experiences. Nieveen's (1997) definition of EPSS includes the integration of job aids (including conceptual and procedural information and advice), communication aids and learning opportunities. And still others are put forth by Stevens and Stevens (1995), Bastiaens (1997) and Collis and Verwijs (1995).

In this study, the notion of electronic performance support is characterized by four main elements: advice, tools, learning opportunities and communication aids, as illustrated in Figure 2.2.

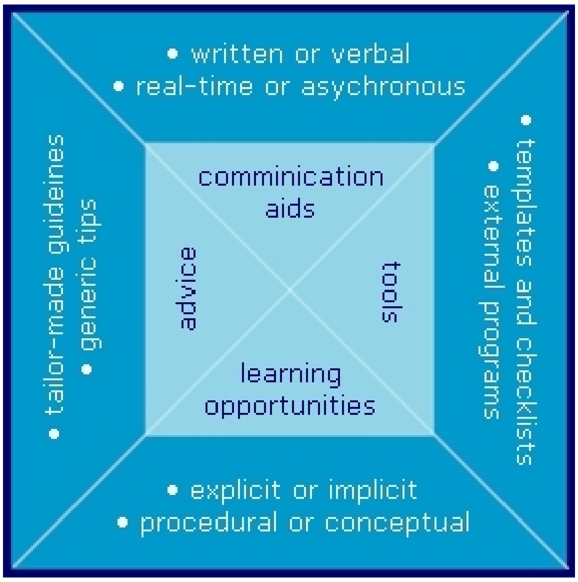


Figure 2.2: Core elements of electronic performance support as defined in this study

Advice refers to tailor-made guidelines that are offered to the user to help carry out a particular task based on what the system knows about the user's needs and context. In addition, advice also includes more generic tips that could be supportive to the user, which are not necessarily based on specific input. Tools in a support system are elements that can assist the user to carry out a certain task. This category includes templates (pre-structured forms that the user need only fill in to use), checklists (lists of things to do or consider) and programs (additional software linked or outside of the EPSS that can be accessed to carry out a task). The learning opportunities category refers to parts of the system that allow users to extend their existing knowledge. This may relate to procedural or conceptual knowledge, and can be offered explicitly (for example, in the form of a tutorial or a help file) or implicitly throughout the system (for example, by structuring activities in certain ways). Lastly, the communication aids category refers to those aspects of the program that facilitate and or stimulate dialogue (written or verbal, real-time or asynchronous).

2.6.3 Benefits and risks

Both developers of various support systems for curriculum development as well as advocates of the concept of EPSS presume several advantages of providing computer support. First, it is assumed that the use of these systems will lead to an improvement in task performance. An EPSS for curriculum development can encourage a more structured approach and further the internal consistency of design decisions (Nieveen, 1997; Gustafson & Reeves, 1990). According to Gery (1991), people will learn to perform their tasks more efficiently with an EPSS than in a traditional training situation. Because an EPSS can provide advice, information and instruction immediately or, 'just in time,' users do not need to remember all issues related to their work, but they can consult the EPSS regarding the issue they want at the time they really need it (Collis, 1994; Nieveen, 1997).

This support can thereby reduce the information load during task performance, and perhaps even increase one's ability to focus on isolated aspects when necessary.

In addition, the use of EPSSs can help promote organizational learning. Most any organization possesses a shared knowledge base: some collection of information regarding techniques, methods and procedures that are common to the work it does. Quite often, this knowledge base grows intuitively; it is not formalized into computer-based or even written form. Further, when individuals change jobs, much knowledge often leaves with them. The idea of organizational learning includes the notion that, through a formal knowledge-capture process, additional relevant knowledge gained by individuals and teams may be stored in the knowledge base. This additional information may then be made available to the whole organization (Stevens & Stevens, 1995). Finally, the use of a computer support system can help forge a common language among curriculum developers and, as a result, increase the quality of communication (Flechsig, 1989).

In discussing the potential benefits of exemplary lesson materials, it was previously noted that materials *on their own* stand to yield far less impact than when embedded in a larger framework such as a teacher inservice program. Similarly, other forms of support (such as a computer program for developing teacher guides) should be designed in such a way as to dove-tail with existing support structures. In this study, a CSCD tool (CASCADE-SEA) was designed to support the ongoing activities at TRCs. This approach was considered most promising because it facilitates a local (regional) approach to national level reform. Through the use of ICT, knowledge, resources and insights in the area of materials development may be captured much more easily and stored for future use. Additionally, they may be shared with other TRCs much more easily, particularly with the advent of the Internet and the proliferation of additional forms of data transmission and storage (for example, cd-writers are becoming much more affordable). In this way, parallel efforts to implement new curricula are then offered increasing opportunities to learn from each other, rather than taking place in isolation.

Naturally, in addition to advantages of computer-based support, some downsides compete with the benefits. Those considering using or developing such a system will need to weigh off the potential gains against the costs and risks that are involved. In terms of initial costs, or investments that may need to be made, a variety of factors come into consideration, related to the users as well as the setting in which the system will be used. In terms of considerations for eventual users, the target audience's motivation to use the computer and level of existing computer literacy should not be neglected. If either one of these is perceived to be low, then time to adjust to and learn how to use the new system will have to be factored in as an additional investment. In addition, an ICT infrastructure must be present in the target environment, so this is considered to be a pre-requisite to being able use such a system. Should the infrastructure not be in place, then it would also constitute an additional cost. Finally, experience has shown that maintenance, updates and changes (technical and content adjustments as well as those based on user preferences) are usually necessary. This represents another category of investment that should be taken into consideration when weighing options.

In addition to initial costs, the users of such systems also bring along with them certain risks. Because it is extremely difficult to measure the effects of an EPSS, one risk is that information regarding the appropriateness of the investment will be difficult to acquire. How will an organization know if their decision to provide computer-based support was a wise one, if they cannot measure the effects of the system? This is a concern which many organizations are now facing due to the rapid changes in not only EPSSs, but general ICT use worldwide. Secondly, the use of powerful tools could lead to de-skilling of staff. If users come to rely too heavily on the computer for support, the potential for them to become 'lazy' begins to exist. Similarly, users may feel threatened by the possibility of losing responsibility or control over their work. Finally, for various reasons, using the computer can, in certain situations, be considered unattractive. Whether for pride-related reasons (experts may feel 'above' the need of support) or a simple dislike of the medium, the computer is not everyone's tool of choice.

A discussion of potential disadvantages related to the use of ICT becomes even more complex when held in terms of developing countries. Haddad et al. (2000, p. 1) aptly summarize much of the concerns shared by educators in developing countries on the topic of ICT in education when they say, ICTs "are not the panacea for EFA [education for all], but can we attain EFA without them? In the poor countries they may not be affordable, but can poor countries afford not to fully use them?" While much remains to be done in terms of enabling developing countries to reap the benefits of ICT in education, there is little doubt that this is one area which is currently bustling with activity. Not only are many efforts focused on expanding access to technology (for an overview of Internet connectivity in Africa, please refer to Jensen, 2000), but many also see technology as a vehicle to improve equity, particularly in terms of access to information (Maltha, Gerrisen & Veen, 1999; Wuisman, 2001). This includes exploring the use of computers by science and mathematics teachers within TRCs (cf. Van der Wal & Pienaar, 1997).

Evidence is now overwhelming that follow-up is essential for effective implementation (Eraut, 1994) and it would seem that the computer presents a reasonable option for such support. In increasingly more cases, in this part of the world, the computer is available when people are not. For example, a busy teacher resource center may have only one facilitator teacher assisting visitors; but for certain tasks, one or two computers could offer assistance when a resource teacher is otherwise engaged or even absent. In southern Africa, many schools experience a high rate of science teacher turnover (Caillods et al., 1996). By storing knowledge into a computer system, it may be saved for future use. In the case of curriculum development, this means that knowledge in the form of completed products (such as teacher guides, lesson ideas, schemes for evaluation, etc.) can be stored in one location and made available to other users of the same system. In addition, less experienced developers can use such a support system to become familiar with the development process within an organization (such as a teacher resource center or an inservice education program) by examining the knowledge and products stored in the system.

The last section of this chapter describes how disadvantages and advantages of creating a support system for curriculum development and teacher development southern Africa were considered. More specifically, it reflects on the ideas presented thus far (relating to curriculum development, teacher professional development and computer-based performance support), and highlights implications for both the product to be developed (CASCADE-SEA computer program) and the research approach.

2.7. Implications for this research

2.7.1 A few words on the adaptation of innovations

Part of the reason for embarking on a study that explores the potential of the computer to contribute to curriculum development and teacher development in southern Africa is the fact that little has actually been done in this area. While many studies have examined inservice education, curriculum reform or even the role of ICT in education within this context, few, if any, have looked at the use of performance support toward the creation of exemplary lesson materials. At the same time, research in other settings has confirmed the notion that the arena of computer supported curriculum development contains great potential to contribute to educational improvement. And, researchers have found that practices or programs developed in one setting can often be used successfully in other places (Loucks-Horsley & Roody, 1990).

Despite the potential insights to be gained through exploration of how ideas may be translated for use in other settings, it should also be noted that such a task is far from easy. "There is no (and never will be any) silver bullet" for educational change in varying contexts (Fullan, 1998). The successful transplantation of ideas depends greatly on an accurate working knowledge of the target setting and a careful analysis of whether a particular innovation would be appropriate there. Neglecting to do so is a common cause for failure, according to Guthrie (1986), who warns against a "lack of fit" of innovations (particularly in developing countries) as a common pitfall. Curriculum development, according to Skilbeck (1998) is a blend of traditional craft ('what works') and the quest for desirable futures ('what is wanted') which displays common features across contexts and yet, is marked by diversity. Here, the challenge is to formulate an alloy that elicits the essence of both craft and quest.

De Feiter et al. (1998, p. 11) discuss this challenge (the adaptation of innovations) with particular regard to southern Africa. "In several countries in southern Africa (e.g. Swaziland, Namibia, Botswana, Lesotho, Zimbabwe) inservice initiatives have been developed that try to use … lessons from the literature on innovation and apply these lessons in various creative ways, appropriate for the circumstances found in the individual countries." They cite various examples of insights in this area, based on their experience. Of those, the following are particularly relevant to this study:

- it pays off to invest much time and effort in the development of teacher support materials that are very specific in the guidelines that are included in them;
- a system of regular inservice workshops needs to be organized regionally or locally to ensure regular participation by as many teachers as possible;
- professional development strategies for teachers should be coordinated with professional development programs for school leadership.

Bearing these ideas in mind, together with the previous discussion of curriculum, teacher development, exemplary materials, TRCs and the use of ICT, the following section discusses design considerations for CASCADE-SEA program.

2.7.2 Design considerations

In the beginning of this chapter, a number of questions were raised relating to the various elements of the conceptual framework presented in section 2.1. Based on this review of relevant literature, discussion now turns to specific implications for the design of the CASCADE-SEA program, revisiting the topics of curriculum development, teacher professional development, exemplary curriculum materials, TRCs and computer-based performance support. Thereafter, essential elements from this discussion are distilled, and tenets that formed the foundation of this study are presented.

Lessons from the literature

As discussed in section 2.2, curriculum relates to various levels, may be viewed from differing perspectives, with varying degrees of versatility. Because this study focuses on developing support for science and mathematics teachers at various TRCs in southern Africa, it concerns a tool which may be classified for use at the meso level, for semi-generic curriculum development (because science and mathematics education are addressed somewhat differently in the various countries). In particular, this support should be offered for decision-making (technical-professional perspective) concerning the creation of curriculum materials (substantive perspective) thus supporting curriculum development from dual perspectives. Aiding the elaboration of the formal curriculum (classroom materials) while working with the perceived curriculum (teacher/developer involvement), this study hoped to help bridge the gap between the ideal and the operational curricula.

Contextual understanding should also be integrated into the way(s) in which teacher development (as described in section 2.3) is addressed through this system. For those who would hastily adopt (or advocate) outside ideas regarding teacher professional development without careful consideration of the context and culture into which they will be sewn, many experts issue warnings. While most of these come in the form of recommendations on how to avoid this (Dove, 1986; Gray, 1999; Ncube, 1998; Ogunniyi, 1996; Rogan, 2000), others look more closely at what to do instead (Aikenhead & Jegede, 1999; Clegg & Osaki, 1998; Knamiller, Osaki & Kuonga, 1995). This is not to say that ideas produced elsewhere can never be of value in different settings. To the contrary, much can be learned from the experiences of others. The point here is that an effort must be made not to underestimate the role of local (cultural, contextual) factors in (re)designing an innovation. Rogan (2000, p. 119) puts it well in his discussion of South Africa's Curriculum 2005, "…any intervention needs to be done *with* and not *for* those involved, and should be appropriate to the needs of the schools and communities affected by the innovation." This insight has formed one of the foundational tenets of the study described in this book, especially in terms of determining how the CASCADE-SEA program can and should link up with professional development frameworks.

When embedding the creation of much needed, low-cost, contextually-relevant lesson materials into teacher professional development programs, certain guidelines should be followed. As addressed in section 2.4, an attempt should be made to maximize the potential benefits offered by exemplary materials (clearly portraying the essence of the innovation, offering concrete examples and stimulating reflection) in part, through the use of procedural specifications. And throughout the processes of developing materials and guiding teachers in how to use them (as well as guiding teachers in how to use the CASCADE-SEA tool itself), the role of teacher as curriculum-maker should be emphasized. This implies that freedom of movement as well as support should be offered to teachers as they explore their 'zone of proximal development' in the curriculum domain.

Such support should be offered to teachers, especially resource (or facilitator) teachers, through vehicles that link up with existing practice as well as cultural and contextual realities, such as TRC activities as described in section 2.5. For example, Ncube (1998) comments on the 'communal design' of TRCs in his country, saying that the collegial atmosphere makes the structure appropriate for Zimbabwe. In addition, he notes that the attempt to create an environment in which sharing of materials and knowledge are encouraged is also culturally appropriate. It may then be inferred that the design of the CASCADE-SEA program should link up with and perhaps even capitalize on these collaborative ideas, thus influencing both the development process and the ICT functions within the tool itself.

Materials developers using a computer-based performance support system to assist in the creation of exemplary lesson materials should be aided as they get in touch with their implicit knowledge about good teaching practice and make it explicit for their colleagues, who will eventually be using the classroom materials. In so doing, the CASCADE-SEA program should (as described in section 2.6) promote improved task performance (better quality materials), organizational learning (among resource teachers) and improved curriculum design and development knowledge (as an element of teacher professional development).

Bearing in mind the (aforementioned) determining role of context within curriculum development, the CASCADE-SEA program should leave value judgements in terms of teaching and learning strategies in the hands of the users, trying to support whatever choice they make, but not aiming to promote any particular pedagogy. For example, some of the manifestations of child-centered learning advocated in Western culture - such as a child being encouraged to question authority - do not sit well in other cultures (Rogan, 2000; De Feiter & Ncube 1999). As a result, CASCADE-SEA should help a user design in a child-centered fashion if that has been selected as the preferred approach. At the same time, teachers and staff associated with the support structures involved should remain responsible for establishing (and encouraging) the specific teaching and learning methods that should be promulgated through the exemplary lesson materials.

Foundational tenets

Meeting all of these criteria is certainly no easy task. While a major source of inspiration for addressing these challenges has come from the literature, the development research approach used afforded the opportunity to continue developing, honing and fine-tuning this product, as well. Based on the insights described throughout this chapter (and highlighted in the previous section), in combination with the development research approach, the following text briefly presents five foundational tenets that influenced the structure of the study.

First, any educational innovation, no matter how brilliantly conceived, must be carefully examined and, if necessary, (re)tailored to be contextually and culturally relevant and meet both the needs and wishes of those for whom it is intended. *Second*, stemming from this notion, is the idea that this can best be achieved when (where appropriate and functional) design and development activities are conducted in *collaboration with* and not *for* those involved. Doing so makes for a complicated work/research environment (since artificial or controlled settings then cease to be a promising option), but can yield tremendous benefits in terms of the richness of the results. *Third*, in a study that focuses on exploring the potential for the computer to offer support to those engaged in the local design of curriculum materials as part of their professional development, efforts must be based on an understanding of the target setting. More specifically, carrying out the research within existing frameworks of teacher education and curriculum development should be a priority. *Fourth*, through careful analysis of these existing frameworks, a skillful attempt should be made to maximize the potential benefits for creating the synergy that should exist between teacher development and curriculum development. *Fifth*, toward that goal, careful analysis of the risks and benefits of computer-based performance support should be conducted in the light of the target setting, with decisions for the design and development of the tool being taken accordingly. Chapter 3 describes how these tenets were translated into a research plan for the exploration of computer-based support for science education materials developers in southern Africa.

Chapter 3

Research design

The CASCADE-SEA research expedition explored the potential of the computer to offer support to (resource) teachers developing materials at Teacher Resource Centers in conjunction with inservice programs. This chapter describes the methods used to carry out the study. After discussing the research questions, the development research approach and related use of prototyping is described. Thereafter, the different groups of experts and users who served as respondents are distinguished, and attention is given to the sampling strategies employed. The chapter concludes by presenting the strategies and methods of data collection, the kinds of instruments used and the different phases of the research.

3.1 Research questions

This research was guided by the following main question: *What are the characteristics of a valid and practical support tool that has the potential to impact the performance of (resource) teachers in the creation of exemplary lesson materials for secondary level science and mathematics education in southern Africa?* The quality aspects of validity, practicality and impact potential that are central to this question were carefully defined.

Validity refers to a product that contains state-of-the-art knowledge which is relevant to the tasks it intends to support, and is offered in an internally consistent fashion. In the CASCADE-SEA tool, such knowledge relates specifically to curriculum development and teacher development, as well as contemporary thinking on how to support these processes. Internal consistency implies that the content, support and interface elements are aligned throughout the various system components.

Practicality implies usability in terms of practical constraints, in addition to linking up with user needs, wishes, attitudes and beliefs; in short, it relates to the way this tool 'fits' with and contributes to the target setting. Further elaboration of this aspect has been inspired by Doyle and Ponder's (1978) 'practicality ethic,' which highlights three important concepts. The notion of instrumentality ('depicting real-world contingencies') relates to the necessity to provide procedural specifications for implementing a demanding task (in this case: creating exemplary curriculum materials) in an actual setting. Congruence (a match between proposed and prevailing conditions), refers to a fit with the way teachers usually conduct (in this case, curriculum development) activities and the teachers' perceptions of the origins of the proposed innovation. Finally, the cost (ratio between amount of return and amount of investment) is calculated in terms of the time, effort and financial resources that must be invested in order to gain returns in time, effort, satisfaction, learning and recognition.

Because this study focused on the design and development (but not the implementation) of a computer supported curriculum development tool, no attempt was made to obtain *conclusive evidence* in terms of overall system effectiveness. However, researchers were keen on learning about the *potential impact* a system like this might have, if implemented on a full-scale. Toward that end, indicators of potential impact were identified in terms of successfully yielding better quality materials (as compared to those materials developed without the aid of CASCADE-SEA) and offering a contribution to enhancing the professional development of the user.

By examining the essence of each of these three criteria, and their implications for program characteristics, additional (more specific) quality criteria were then established. These aspects, pertaining to program content, the support offered to the user and interface (and technical) characteristics, are summarized in the Table 3.1.

The table (right) describes the departure points for establishing quality criteria for designing and developing the CASCADE-SEA program. Yet it is commonly accepted that criteria for quality are relative to a given situation and not absolute. Toward learning more about the characteristics of a tool that meets the above-mentioned criteria within the context of science education in southern Africa, a development research approach was employed. Highlights of this approach and the related role of prototyping are addressed in the following section.

	Key Issues	Content	Support	Interface
Validity	*State of the art knowledge*	Curriculum design and development knowledge Related professional development knowledge	Advice on materials design Guidance on embedding materials in professional development	Maximizes the potential of modern ICT facilities
	Internally consistent	Ideas in various components are in line with those in other areas	Tips, guidelines, templates, advice and help functions are perpetually offered in a consistent fashion	Functions as intended, regularly
Practicality	*Instrument-ality*	Guides the user step-by-step in making materials Offers freedom to work at own pace and in own style	Explains how to use program clearly and concisely	Buttons, navigation and functions are clear
	Congruence	Links up with the needs, wishes and context of the users	Support is relevant and usable	Interface 'feels' nice and safe, users are not alienated but motivated to use the program Operates on technology that is available in the target setting
	Cost	Content should include enough of what users need, and not bog them down with unnecessary steps	Support should be extensive, lowering the threshold of investment cost to the user	Interface should reflect the flexibility of the system, in which users determine how they would like to go through the program (maximum degree of freedom, minimum allowance for error)
Impact Indicators	*Yields better quality materials*	The materials that are developed through use of CASCADE-SEA should be valid, practical and effective	The materials that are created with CASCADE-SEA should contain clear, useful procedural specifications	The materials that are generated with CASCADE-SEA should evidence attention given to form and style
	Enhances the professional development of users	CASCADE-SEA should help users to think about materials development in a (more) systematic and thorough fashion	Teaches users where resources can be found (inside the program), and how they may be used and/or adapted for own setting	Interface helps (teams of) users to visualize the process of materials development and make their work more transparent

Table 3.1: Quality criteria for designing, developing and evaluating the CASCADE-SEA program

3.2 Development research approach

Chapter 2 featured a review of relevant literature on the topics related to this study, and concluded with five tenets that influenced its structure. These tenets related to the issues of: local relevance, collaboration, authenticity of the research setting, intensifying the synergy that should exist between curriculum development and teacher development and the importance of careful, continuous analysis and (re)evaluation of the target setting. Each of these tenets implies that significant attention be given to the uncertainties and complexities that comprise educational realities. With this in mind, a development research[4] approach was selected because of the opportunities it yields in this regard. The relationship between this approach and the five tenets guiding the structure of the study is described in the following paragraphs.

3.2.1 Local relevance

While the notion of designing educational innovation from an implementation perspective is not a new one (cf. Van den Akker, 1994), determining how to factor in cultural and contextual realities remains a challenge. Tessmer and Harris (1990) speak of a potential conflict of interest between following sound instructional design practices while also paying attention to 'real world' challenges and limitations. They make a distinction between 'doing things right' and 'doing the right things' in instructional design. Development research (particularly formative research) speaks to this potential conflict through the combination of careful design based on validated models ('doing things right') that is then tested and revised in practice (increasing the chance for 'doing the right things'). Such successive approximation of interventions in interaction with practitioners distinguishes development research from other research approaches (Van den Akker, 1999). Evolutionary development (fed by information from research activities), yields greater opportunity for coping effectively with contextual factors that may not have been present, evident or articulated during earlier phases of development. This increases the practical relevance of that which is being designed which, in turn, affords deeper insights into good design practice for that particular setting.

4 Development research has been defined as "the systematic study of designing, developing and evaluating instructional programs, processes and products that must meet the criteria of internal consistency and effectiveness," (Seels & Richey, 1994). For additional information on development research, please refer to Richey and Nelson (1996), Van den Akker (1999) or Reeves (2000).

3.2.1 Collaboration

In a study such as this one, where significant emphasis has been placed on (re)tailoring initial design ideas to best fit the context, the notion of collaboration bears mention, for three reasons. It was stated in Chapter 2 that the design and development activities should (where feasible and functional) take place in collaboration with and not for those involved. While this may add complications to the design process, the potential benefits of a participatory design process make it worthwhile. A participatory design approach distinguishes itself from other, more traditional approaches by (among others) assuming that users themselves are in the best position to determine how to improve their work and professional environment. Further, "it views the users' perceptions of technology as being at least as important to success as fact, and that their feelings about technology are at least as important as what they can do with it," (Schuler & Namioka, 1993, p. xi). In the case of CASCADE-SEA, user involvement was thought to help establish a better fit in terms of system design. That is, the input of (potential) users helped designers to better understand the context in which it would be used, as well as to sharpen their understanding of the users' needs. Secondly, this approach can simultaneously foster ownership on behalf of the users, thus increasing the potential for the innovation to become accepted and implemented (or at least tried out) in the target setting. Finally, as with the creation of lesson materials (discussed in Chapter 2), participating in the development process can contribute to professional growth. As researchers and respondents jointly reflect on how curriculum development (should) take(s) place and how that could be supported through the computer, both parties learn from the experience (cf. Nieveen, 1997).

3.2.3 Authenticity

In order to do this, the design and development activities for CASCADE-SEA should be integrated, where possible, with the existing curriculum materials development endeavors taking place in the framework of inservice education (or, in some cases, preservice education). This occurs usually, but not exclusively, at teacher resource centers. Using a concurrent design approach, prototypes of the program can be developed together with the users even while doing additional situational analysis (Tessmer & Wedman, 1995). Such activities should optimize the link between teacher development and curriculum development within the given setting, with the local participant groups. They should also serve to increase the authenticity - and thereby, overall richness and value - of the results.

3.2.4 Mutual benefit

Embedding research activities into an existing framework of teacher professional development requires that the researchers exercise caution as well as creativity in selecting data collection methods. It must be made clear to the researchers, as well as those participating in the study, that the goals of the activities are not only related to developing the CASCADE-SEA prototype. Rather, these activities must also serve the professional development of the participants. Thus, researchers should be careful to maintain this dual focus throughout the data collection activities, which may require creative approaches to collecting useful information while maintaining care for the better interest of those involved.

3.2.5 Continuous (re)analysis

One way to maintain this dual focus is through the use of prototyping. Prototyping has traditionally been associated with engineering fields of study. Yet through time, this has grown to include other arenas that apply a systematic approach to problem-solving and design. Connel and Shafer (1989) identify five forms of prototypes: throw-away, quick and dirty, detail design, non-functional mock-ups and evolutionary. Tessmer (1994) notes that the advent of prototyping allows evaluators to review functional versions of products at an early stage, thus making formative evaluation more a part of the front-end analysis and design. This study should involve users in the design process by continuously field-testing working evolutionary prototypes. For additional information on prototyping to reach product quality, please refer to Nieveen, (1999).

The development research approach was not only selected because the methods involved are appropriate for studying design and development efforts with an evolutionary character. Moreover, the inherent priorities on information richness and efficiency were considered an asset, as well as the fact that development research is usually attuned to a shifting emphasis on quality criteria. During the course of study, development research methods and techniques for evaluation shift in emphasis from an initial focus on validity, to that of practicality and eventually - as that which is being developed matures - to exploring the impact. For more detailed information regarding principles and methods of development research, please refer to Van den Akker, (1999); Richey & Nelson, (1996); or Reeves, (2000).

Ultimately, a development research approach yields insights not only into how to improve, or even optimize, that which is being developed; it also affords better understanding of the design process itself. These insights often take the form of design principles, both substantive and methodological, to support (future) designers in their task (Van den Akker, 1999). The CASCADE-SEA study has also sought to gain knowledge about both the product (computer program) and the process (of design and development as part of a professional development scenario) that could be presented in the form of design principles.

While development research offers many benefits and opportunities, such an emergent approach also demands that attention be given to the resulting consequences in terms of how a study is designed, as Smith (1990, p. 209) indicates:

> *"Whether emergent programs are more developmental, driven by the attainment of programmatic goals, or more adaptive, responsive to certain pressures forcing programmatic change, they are characterized by rapid, often dramatic, changes which make the creation and implementation of stable evaluation designs very difficult. Successfully evaluating such programs requires a certain degree of flexibility in the design and conduct of the evaluation study."*

The following sections describe how this was undertaken, starting with a discussion of the respondent groups involved.

3.3 Sampling

During the period in which this study took place, the University of Twente established a formal relationship with the Vrije Universiteit Amsterdam, whose history of educational development cooperation has been especially strong in southern Africa. This step resulted in an organization called DECIDE, the Dutch Expertise Consortium for International Development of Education. As described in Chapter 1, part of the impetus for carrying out this study was inspired through increased collaboration with various curriculum and teacher development programs in the southern African region. Said increase was largely due to the establishment of DECIDE, in terms of the formal and informal relationships that were strengthened as a result.

Many of the ideas related to shaping both the tool and the research were born out of dialogue with staff from projects and programs that were, in some way, connected with DECIDE. A common characteristic among many DECIDE initiatives is the creation of exemplary curriculum materials; oftentimes this is in combination with a professional development program. Given the shared areas of interest between DECIDE programs and the CASCADE-SEA study, the opportunities for designing research activities that would be mutually beneficial were plentiful.

With the goal of obtaining meaningful insights into the desired characteristics of a program such as the one proposed (and the context in which it would be used), sampling decisions were made accordingly. Rather than basing choices on a quest for generalizeability, procedures were sought that would yield access to: naturally-occurring test-beds; variation in terms of countries and organizations involved; and the flexibility to tailor planning as research insights developed. For these reasons, the following combination of strategies was selected for use within this study: chain referral (or snowball) and (stratified) purposeful sampling (Krathwohl, 1993; Miles & Huberman, 1994).

Chain referral (or snowball) sampling involves searching out new leads; the uniqueness of this form is that opportunities of interest are identified by (other) people who know people who can identify such opportunities. To illustrate, one of the CASCADE-SEA prototype evaluations was carried out within a teacher development program in South Africa. This came to pass after the following chain of events: (1) University of Twente staff attended meetings at the World Bank in Washington DC, and (2) returned with an invitation for other University of Twente staff to (among other things) present their research to World Bank colleagues. Following up on this invitation, (3) the primary developer of the CASCADE-SEA program discussed the study with the (World Bank) group, which later led to (4) participation in a set of case studies on innovative practices using technology in teacher education (the CASCADE-SEA study was one of the cases). Knowing the nature of the different cases involved, (5) the coordinator of the World Bank case study project arranged a meeting between the CASCADE-SEA researcher and the program director for another one of the cases in the project (the Shoma Foundation), intending to stimulate collaboration. This attempt was successful, and yielded a new and unique setting for CASCADE-SEA prototype testing (for details on this portion of the study, please refer to section 3.4.3, Activities Overview). This vignette not only illustrates how chain referral sampling was employed, but also shows the emergent nature of the research design.

The study described in this book was primarily conducted through successive evaluation of four computer-based prototypes. Each prototype was evaluated with a number of groups (ranging from two to six different groups per prototype). While chain referral (or snowball) sampling best characterizes the strategy used for making sampling decisions with regard to each individual group, stratified purposeful sampling was used to facilitate comparisons between types of groups. The two types participants in this study were user groups and expert groups. The user group included preservice teachers (this group became involved as a result of the study's emergent nature and the aforementioned chain referral strategy), inservice teachers (emphasizing resource or facilitator teachers) and curriculum developers. The expert groups consisted of science education experts, curriculum development experts and experts in the area of computer-based performance support. Earlier stages of the study (focused more on understanding validity-related criteria) involved a higher degree of experts than those in later stages, which examined the practicality and potential impact of the CASCADE-SEA program. In such later stages, user groups played a more prominent role in evaluation activities.

Krathwohl (1993) makes a distinction between subjects in experimentation and informants that participate in research activities. This mainly relates to the idea that the latter are viewed - and treated - as individuals from which to learn. As illustrated in the (forthcoming) descriptions of research activities, such a perspective also characterizes the role of respondents (i.e. as participants) in this study. The next section of this chapter discusses how an attempt was made to learn from the various user and experts groups, by delineating the data collection methods.

3.4 Data collection

Parameters	Opportunities used
Settings	▪ Teacher resource centers ▪ Teacher training colleges and universities ▪ Curriculum development institutes ▪ Conferences
Actors	▪ Users: preservice teachers, inservice teachers, curriculum developers ▪ Experts in: science education, curriculum development, computer-based performance support
Events	▪ Workshops ▪ Meetings ▪ Interactive presentations
Methods	▪ Interviews and walkthroughs ▪ Questionnaires ▪ Discussions ▪ Observations and demonstrations ▪ Logbooks ▪ Document analysis

Box 3.1: Data collection parameters

In order to understand the activities described in the following section, it may be useful to begin by providing an overview of the settings, actors, events and methods through which data were collected. Box 3.1 offers an overview of these parameters. Thereafter, data collection procedures are described in terms of the phases of the study and the strategies and methods used throughout the four-year period. The last part of this section presents more detailed information on these aspects, related to each individual research component.

3.4.1 Three main phases

Within this study, three main phases may be distinguished: needs/context analysis; design/formative evaluation of prototype tools; and a more summative assessment of the final product (including exploration of its value for other contexts). The primary goal of the analysis phase was to obtain a working knowledge of the target setting, user group and areas in which a support tool may be put to work. The previous exploration into computer-based support for curriculum developers described in Chapter 1 of this book yielded a tool (CASCADE) that served as a springboard throughout this study, especially in the analysis stage. For detailed information on this research, please refer to Nieveen (1997). This phase consisted of two main cycles. Beginning with a study of relevant literature (discussed in Chapter 2) and interviews with experts and professional curriculum developers, the analysis phase culminated in visitation to various curriculum development/teacher development programs in southern Africa. During the visitations, an English version of the CASCADE tool (designed for the SLO) as well as initial analysis findings were presented to expert and user groups who were involved in materials development as part of an inservice scenario. They offered feedback in the form of initial design ideas, as well as tentative suggestions for future cooperative activities.

The design and development phase relied heavily on the cooperation of these (and other) institutions and individuals. Through iterative cycles of design, development and prototype evaluation, the CASCADE-SEA tool evolved. The main criteria upon which these (four) prototypes were evaluated during the design and development phase were validity and practicality.

The end evaluation phase of this study explored the potential impact of the CASCADE-SEA system in terms of (potential) contributions to teacher development and curriculum development as a result of its use. This phase may best be described as 'semi-summative' in nature. This is because the end evaluation mainly possessed characteristics of summative evaluation (in particular, the aim), but maintained a number of formative evaluation elements as well.

Parameters	**Formative**	**Summative**
Aim	Intent to improve evaluand	**Basis for decision-making**
Application	Varied types of improvements e.g.: ▪ Optimizing the development process ▪ Fine-tuning the product	**Varied types of decisions e.g.:** ▪ **Implementation** ▪ **Generalizatability** ▪ Go/continue/stop support or efforts ▪ Purchase
Timing	During development	**After completion (or stabilization)**
Audience	**Internal**	**External**
Evaluator	Usually **internal** (could also be external or both)	Usually external (could also be **internal** or both)
Methods	**Exploratory**, flexible	**Unobtrusive**, pre-determined
Instrumentation	**Varied, many, locally-developed** or standardized	**Reliable**, validated, publically accepted

Box 3.2: Semi-summative evaluation (bold, black text pertains to CASCADE-SEA end phase)

Lewy (1990) and Scriven (1994) describe distinctions between formative and summative evaluation. Synthesis of these descriptions shows that the differences pertain mainly to seven parameters: *aim* (of the evaluation); *application* (how the information will be used); *timing* (in relation to the development of the evaluand); *audience* (who will use this information); *evaluator* (in relation to that which is being evaluated); *methods* (of investigation); and *instrumentation* (used to collect data). Box 3.2 (previous page) illustrates these differences. To show why the term semi-summative has been chosen, bold, black text indicates the aspects that apply to the end evaluation of the CASCADE-SEA study. An additional research activity that took place within this evaluation phase was an explorative query of other contexts and situations in which this tool (or a revised version thereof) might be useful.

Figure 3.1 displays the study's three main phases (analysis, design and evaluation) and the scope of the eight cycles within the phases (in terms of participants involved and time spent).

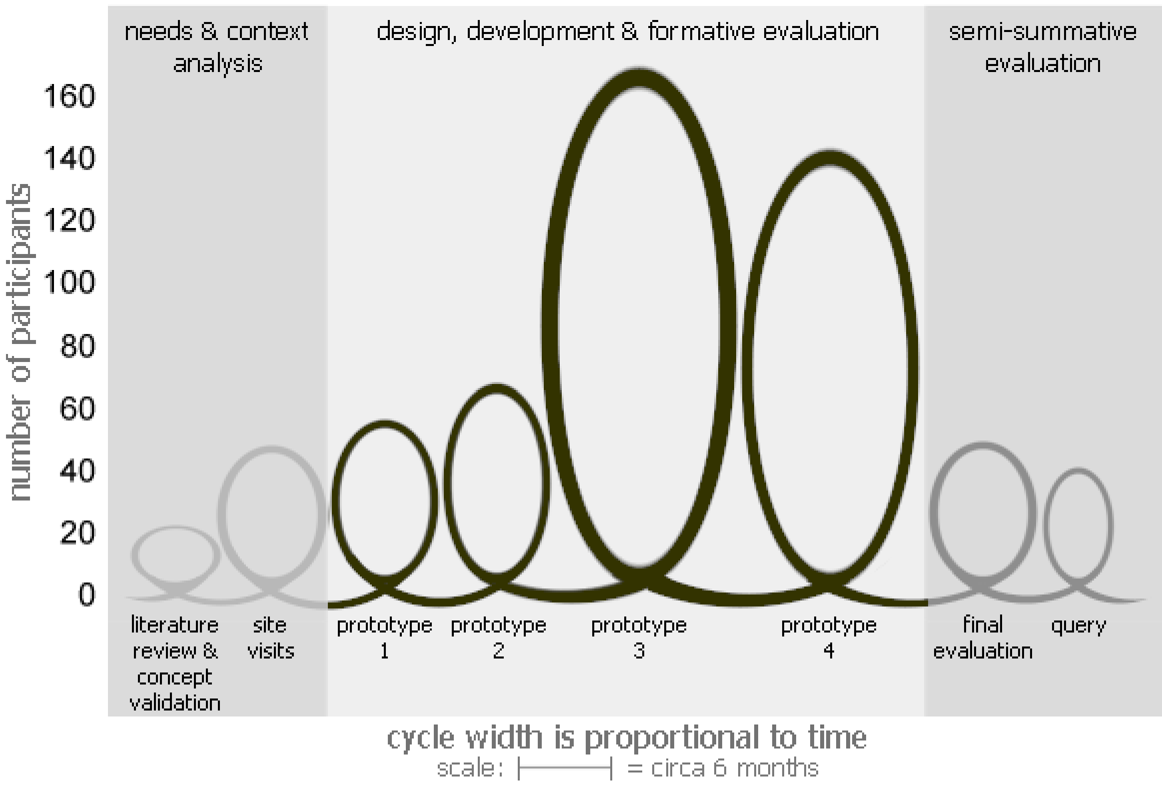


Figure 3.1: Display of the CASCADE-SEA study

The remainder of this section details activities that took place within each phase and cycle illustrated here. Four general strategies are outlined first, along with the methods used within each one. An overview of all research activities is then presented. After the relationship between the various activities and the research questions is addressed, this section concludes with discussion of the types of instruments developed throughout the study.

3.4.2 Strategies and methods

Definitions

Across the three phases of research, four basic strategies were used: screening, expert appraisal, micro-evaluation and tryout (cf. Nieveen, 1997). A screening is conducted by the developer(s) and involves a comparison of that which has been developed and the initially defined desired characteristics. A screening is usually conducted with the aid of a 'walkthrough' document or (set of) checklist(s) that articulate design principles to varying degrees of specificity. Each prototype (design and development phase) underwent developer screening.

In an expert appraisal, experts are solicited for feedback on that which has been developed. This may be as concrete as a working prototype, or as abstract as global design principles. Such commentary is collected through interviews or questionnaires, often during or after a presentation of that which is to be evaluated. Each prototype (in the main phase of the research) was subjected to expert appraisal with at least one of the aforementioned expert groups. The final version of the CASCADE-SEA program (evaluation phase) also made use of this strategy.

The micro-evaluation strategy is used to evaluate prototypes with small groups of users or experts. Here, the prototype is trialled/presented outside of the intended (or target) setting. The micro-evaluation strategy was used mostly during the design and development phase of the study. To collect data using this strategy, the following methods were used: interviews, questionnaires, discussions, observations, logs and document analysis.

Finally, a tryout means that the evaluand be tested by the target group in the target setting. The tryout strategy was used mostly toward the end of the design and development phase, and during the evaluation phase. To collect data using this strategy, interviews, questionnaires, discussions, observations, logs and document analysis were also used.

In each of the three main phases of this study, two or three of these strategies were applied, as illustrated in the following table. Table 3.2 is organized by phase, cycle and circuit. As previously mentioned, the analysis and evaluation phases contained two cycles, and the design phase contained four cycles. Each cycle consisted of various circuits, involving different groups of actors (some more than once). These circuit descriptions are denoted by numbered sequence, group name and (if applicable), that group's participation number (e.g. NL2 refers to the second cycle in which the Dutch expert group participated). Detailed descriptions of circuit activities may be found in section 3.4.3; the boxed text explains the abbreviations used in circuit names. Further, Appendix A provides an overview of all circuits.

Phase	Cycle	Circuit sequence and name	Strategy				Participants						#
							Users			Experts			
			DS	EA	ME	TO	PS	IS	CD	SE	CD	PS	
Needs and context analysis	Literature review & concept validation	1: NL1		X						X	X	X	5
		2: AMSTIP		X						X	X	X	5
		3: TEAMS1		X						X	X		3
		4: SEITT1			X					X	X		5
	Site visits (discuss-ion tool)	5: SAARMSE		X						X	X	X	24
		6: UB			X		X		X	X	X		27
		7: TEAMS2		X						X	X		3
Design, development and formative evaluation of prototypes	Prototype 1	8: DEV1	X							X	X	X	4
		9: PSU/UGA/USA		X							X	X	15
		10: NL2		X						X	X	X	19
		11: NL3		X							X	X	12
	Prototype 2	12: DEV2	X							X	X	X	4
		13: SEITT2			X		X		X	X			25
		14: TEAMS3				X		X	X	X	X		34
	Prototype 3	15: DEV3	X							X	X	X	4
		16: SW		X						X	X		12
		17: UN		X							X		3
		18: SEITT3		X				X	X	X	X		10
		19: SEITT4*			X			X	X	X	X		33
		20: TEAMS4*			X		X	X	X	X	X		18
		21: UNESCO1*			X		X		X		X		19
		22: PTLC*			X			X					18
		23: RSA1*			X			X					30
		24: RSA2*		X						X	X		22
	Prototype 4	25: DEV4	X							X	X	X	4
		26: NAM		X						X	X		11
		27: CET*				X		X	X				11
		28: SEITT5				X		X	X	X	X		44
		29: UNESCO2*			X		X	X					54
		30: SHOMA*				X		X	X				16
Semi-sum-mative evaluation	Final evaluation	31: TEAMS5				X		X	X				19
		32: NL4		X						X	X	X	17
		33: NSDSI				X		X	X				9
	Query	34: QUERY			X		X	X	X	X	X	X	34
		Totals:	**4**	**14**	**10**	**6**	**6**	**13**	**13**	**23**	**26**	**12**	**573**
Estimated total respondents when corrected for those who participated more than once:													**510**

Table 3.2: Activity overview

Legend ▒ = Strategies used; ■ = Types of respondents
* = Carried out completely or in part by someone other than the primary researcher/developer
Strategies: DS=developer screening; EA=expert appraisal; ME=micro-evaluation; TO=tryout
Users: PS=preservice teachers; IS=inservice teachers; CD=curriculum development;
Experts: SE=science education; CD=curriculum development; PS=performance support

Research activities and research questions
In discussing the link between the research activities illustrated in Table 3.2 and the main questions (particularly the quality aspects that were explored throughout the study), it may be useful to return to the notion of emergent design. As stated in section 3.2, a development research approach was selected because of the many benefits and opportunities it presents to this particular study. At the same time, such an emergent approach also demands that the study be designed with a certain degree of flexibility. Section 3.3 discussed these implications in terms of the sampling procedures used. Here, the selection of data collection activities is examined in light of the need for flexibility.

As mentioned in the beginning of this chapter, the focus on quality aspects gradually shifted from validity to practicality throughout the research, only tentatively exploring the potential impact of the system toward the final (evaluation) phase. This change in focus reflects what was considered to be a natural course of events. If a product is known to be invalid or impractical, the chances of it being able to yield the desired impact can be safely estimated as low. As a result, the qualities of validity and practicality have been interpreted as prerequisites for bearing impact potential. Because this study focused on the design and development of the CASCADE-SEA tool, the definitive bulk of information gathered relates to these two areas.

While this gradual shift in focus shaped the study's design in general, additional factors affected decisions regarding specific data collection activities. As previously described, the six participant groups (three types of users and three types of experts) were selected, as were the four main strategies, because these were perceived to be the most promising avenues toward answering the main research questions. As Miles and Huberman (1994, p. 29) put it, "Choices of informants, episodes, and interactions are being driven by a conceptual question, not by a concern for 'representativeness.' To get to the construct, we need to see different instances of it, at different places, with different people." The structure of this study was shaped by the desire to explore many 'different instances' of participant perceptions. As a result, a wide variety of data collection activities was undertaken.

Each time a data collection opportunity arose, researcher/developers weighed off perceived costs (time, finances, etc.) with estimated benefits (e.g. depth and validity of prototype feedback), in accordance with the tenets that guided this study. Many activities were eventually conducted even when the perceived benefit was relatively low, because (as long as the related costs were also minimal), this was considered a low-risk method of exploring what types of 'different instances' would actually yield the most fruitful data. In this study's design, decisions related not only to that which would be *absolutely necessary* to answer the research questions, but to *how well* the questions could be answered.

Given the aim of this research, no finite minimum of data collection activities could be established ahead of time, to answer the research questions. Rather, throughout the study, research design decisions were influenced by the goal of meeting the following triangulation criteria: (cf. Krathwohl, 1993):

- Data sources: varying time, location and people
- Methods: varying formats (e.g. interviews, observations, etc.)
- Investigators: varying researchers (or assistants)

Within each cycle, data source and method triangulation was achieved through the variation in circuit activities. Where possible, investigator triangulation was also attained (as indicated by the * in Table 3.2).

Table 3.3 (next page) illustrates the relationship between the data collection activities that were undertaken and the main research questions, highlighting the fact that not all circuits were entered into with equal expectations in terms of results. It reconstructs the researcher's perceptions at the *start* of each circuit, while also representing the researcher's perceptions *after* each activity was conducted. As hoped, some activities that appeared less likely to yield significant findings turned out to offer more than foreseen; the opposite is also true. In both cases, the gradual shift from studying validity, then practicality and then impact potential may be seen. The circuit data are reflected in Table 3.3 through grey-scale shading, indicating those that offered no (white), low (light grey), medium (medium grey) and high (dark grey) contributions. These shades are based on the researcher's interpretation of the *salience* and *intensity* of the data, not particularly on the volume. The classifications themselves (no, low, medium, or high) exerted little influence on the analysis of the data, (in fact, the classifications listed in the 'after' columns were made following data analysis). However, it follows logically that there is a correlation between those with medium and high ranking, and those contributions that are given extended treatment in the presentation of results in Chapter 5. Because of the insights yielded through tracking the perceived (before) and actual (after) contribution rankings, this issue will be discussed further in Chapter 6.

Finally, it should be emphasized that the individual circuits of activity emerged in dialogue with potential participants in the study, as well as the cost-benefit analysis mentioned previously. This kind of flexibility was built into the study, so that knowledge and findings from previous circuits of activity could then be applied to subsequent ones. Further, consideration of participant suggestions, even with regard to data collection opportunities, was consistent with the relational approach as advocated through the foundational tenets.

		Circuit Sequence and Name	Data Contribution Overview													
			Before							After						
			V		P			I		V		P			I	
			SAK	INC	INS	CON	COS	BQM	EPD	SAK	INC	INS	CON	COS	BQM	EPD
Needs and context analysis	Literature review & concept validation	Circuit 1: NL1	High	Medium	Medium	High	Low	None	None	High	Low	High	High	Low	None	None
		Circuit 2: AMSTIP	Low	None	Low	Medium	Low	None	None	Low	None	None	None	None	None	None
		Circuit 3: TEAMS1	Medium	Low	Medium	Medium	None	None	None	Medium	None	Low	Low	None	None	None
		Circuit 4: SEITT1	Low	Low	Medium	Medium	Low	None	None	Low	Low	Low	Medium	None	None	None
	Site visits (discussion tool)	Circuit 5: SAARMSE	Medium	Medium	High	High	High	None	None	High	Low	Medium	High	Medium	None	None
		Circuit 6: UB	Low	Low	Low	Low	Low	None	None	Low	None	Low	Low	None	None	None
		Circuit 7: TEAMS2	Low	Low	Medium	Medium	Medium	None	None	Medium	None	Low	Medium	None	None	None
Design, development and formative evaluation of prototypes	Prototype 1	Circuit 8: DEV1	High	High	Medium	Medium	Medium	Low	None	High	Medium	Medium	Low	Medium	None	None
		Circuit 9: PSU/UGA/USA	High	High	Medium	Low	Medium	None	None	High	High	High	High	High	None	None
		Circuit 10: NL2	High	High	Medium	Medium	Medium	None	None	High	High	High	High	High	None	None
		Circuit 11: NL3	Medium	Medium	High	High	High	None	None	High	Low	Medium	Low	Low	None	None
	Prototype 2	Circuit 12: DEV2	High	High	Medium	Medium	Medium	None	None	Medium	None	Low	Medium	Medium	Low	None
		Circuit 13: SEITT2	Medium	Medium	Medium	High	Low	None	None	Medium	Low	None	High	Medium	None	None
		Circuit 14: TEAMS3	Medium	Medium	High	High	Medium	Low	None	High	Medium	High	High	Medium	Medium	Medium
	Prototype 3	Circuit 15: DEV3	High	High	Medium	Medium	Medium	Low	Low	High	High	Medium	Medium	Low	Low	Low
		Circuit 16: SW	Low	Low	Low	Low	Low	None	None	Low	Low	Low	Low	Medium	None	Low
		Circuit 17: UN	None	None	Low	Low	None	None	None	None	None	Low	Low	None	None	None
		Circuit 18: SEITT3	None	None	None	Low	Low	None	None	None	None	None	Low	Low	None	None
		Circuit 19: SEITT4	Low	Medium	High	High	High	Low	None	Low	Medium	High	High	High	Medium	High
		Circuit 20: TEAMS4	None	Low	High	High	Medium	Low	Low	None	Low	Medium	High	Medium	Low	None
		Circuit 21: UNESCO1	None	Low	Medium	Medium	Low	Low	Low	Low	Low	High	High	Low	Medium	Low
		Circuit 22: PTLC	Low	Medium	High	High	High	Low	Low	None	None	High	High	High	Medium	None
		Circuit 23: RSA1	Medium	Medium	High	High	High	Low	Low	Low	Medium	High	High	Medium	Low	Low
		Circuit 24: RSA2	Low	None	Low	Low	Low	Low	None	Low	None	Low	Medium	Low	Low	Low
	Prototype 4	Circuit 25: DEV4	Medium	Medium	Medium	Medium	Medium	Low	Low	High	Medium	Medium	Medium	Medium	None	None
		Circuit 26: NAM	None	Low	Low	Low	Low	None	None	Low	None	Low	Medium	High	None	Low
		Circuit 27: CET	None	Low	Low	Low	Low	Medium	Medium	None	None	Low	Medium	Low	Low	Medium
		Circuit 28: SEITT5	None	Low	High	High	High	Medium	Medium	None	Low	High	High	High	High	High
		Circuit 29: UNESCO2	None	Low	High	High	Medium	Low	Medium	None	None	None	High	Low	Low	Medium
		Circuit 30: SHOMA	Low	Low	High	High	High	Medium	Medium	Low	None	Medium	High	Medium	High	High
Semi-summative evaluation	Final evaluation	Circuit 31: TEAMS5	Low	Low	Medium	Medium	Medium	High	High	None	None	Low	Medium	Medium	High	High
		Circuit 32: NL4	Low	Low	Medium	Medium	Medium	High	High	Medium	Low	Medium	Medium	Medium	High	High
		Circuit 33: NSDSI	Low	Low	Medium	Medium	Medium	High	High	Low	Low	Medium	High	Medium	High	High
	Query	Circuit 34: QUERY	In addition to touching lightly on these aspects, the query was intentionally designed to explore other areas													

Table 3.3: Circuit and data weight overview table

Legend ☐ = None; ☐ = Low; ☐ = Medium; ☐ = High
V=Validity: SAK=state-of-the-art knowledge; INC=internal consistency
P=Practicality: INS=instrumentality; CON=congruency; COS=cost
I=Impact: BQM=better quality materials; EPD=enhances professional development

Instrumentation
Instruments were developed to use along with each of the four strategies defined at the beginning of this section. While variation exists among like kinds of instruments, so do similarities. For example, various interview schemes were designed to gather information about the same aspects (internal consistency of the program interface, for example), while being used in different settings. In such a case, rather than develop completely new instruments, researchers often tailored existing ones. Additionally, instruments were improved wherever possible, based on insights acquired through previous uses. This approach has resulted in 'instrument families' containing like kinds of instruments with related roots but also certain degrees of variation. Six main families of instruments are distinguished:

- Interview and walkthrough schemes
- Questionnaires
- Discussion guides
- Observation and demonstration schemes
- Logbooks
- Document analysis checklists

Table 3.4 (next page) presents an overview of the 108 instruments used in this study. The instrument codes used throughout this book and on the (enclosed) CD-ROM include reference to both the type of instrument and the circuit in which it was used. As previously mentioned, the analysis, design and evaluation phases contained varying numbers of cycles; each cycle consisted of several circuits.

In this table, the circuit is denoted by both name (abbreviation) and sequence suffix (number). For example, DG-SAARMSE:5 refers to the discussion guide used with the SAARMSE group during the fifth circuit. Additional information regarding all instruments and respondents is located in Appendix B. The instruments themselves, are located on the CD-ROM at the back of this book (see Appendix C). Following the table below, section 3.4.3 discusses the various phases, cycles and circuits of activity (including instruments used) in more detail.

Phase	Cycle	Interview & Walkthrough Schemes	Questionnaires	Discussion Guides	Observation & Demo Schemes	Logbooks	Document Analysis Checklists
Analysis	*LR*			DG-SEITT1.4	D-NL1.1 D-AMSTIP.2 D-TEAMS1.3		
	SV	IS-UBINSET.6 IS-TEAMS2.7	Q-SAARMSEa.5 Q-SAARMSEb.5 Q-SAARMSEc.5	DG-SAARMSE.5 DG-UBINSET.6			
Design, Development and formative evaluation	*P1*	W-DEV1.8 IS-PSU/UGA/ USA.9 W-NL2.10		DG-NL3a.11 DG-NL3b.11 DG-NL3c.11 DG-NL3d.11	D-PSU.9		
	P2	W-DEV2.12	Q-TEAMS3.14	DG-TEAMS3.14	D-SEITT2.13 O-TEAMS3.14		DA- TEAMS3.14
	P3	W-DEV3.15 IS-SEITT4.19 IS-TEAMS4.20 IS-UNESCO1.21 IS-PTLC.22	Q-SEITT4a.19 Q-SEITT4b.19 Q-SEITT4c.19 Q-TEAMS4a.20 Q-TEAMS4b.20 Q-TEAMS4c.20 Q-TEAMS4d.20 Q-TEAMS4e.20 Q-UNESCO1a.21 Q-UNESCO1b.21 Q-PTLCa.22 Q-PTLCb.22 Q-PTLCc.22 Q-PTLCd.22 Q-PTLCe.22 Q-RSA1a.23 Q-RSA1b.23 Q-RSA1c.23 Q-RSA2.24	DG-SW.16 DG-SEITT4.19 DG- UNESCO1.21 DG-PTLC.22 DG- RSA1.23 DG-RSA2.24	D-UN.17 D-SEITT3.18 O-SEITT4.19 O-TEAMS4.20 O-UNESCO1.21 O-PTLC.22 O- RSA1.23	L-SEITT4.19 L-UNESCO1.21 L- RSA1.23	DA- SEITT4.19 DA- TEAMS4.20 DA- UNESCO1.21
	P4	W-DEV4.25 IS-SHOMAa.30 IS-SHOMAb.30 IS-SHOMAc.30	Q-NAM.26 Q-CETa.27 Q-CETb.27 Q-SEITT5a.28 Q-SEITT5b.28 Q-UNESCO2.29 Q-SHOMAa.30 Q-SHOMAb.30 Q-SHOMAc.30 Q-SHOMAd.30	DG-NAM.26 DG- CET.27 DG-SEITT5.28 DG- UNESCO2.29	O-CET.27 O-SEITT5.28 O-UNESCO2.29 O-SHOMAa.30 O-SHOMAb.30	L-UNESCO2.29	DA- SHOMA.30
Eval- uation	*FE*		Q-TEAMS5a.31 Q-TEAMS5b.31 Q- NL3.32 Q-NSDSI.33	DG-TEAMS5.31 DG- NL3.32 DG-NSDSI.33	O-TEAMS5.31 O-NL3.32 O-NSDSI.33	L-NSDSI.33	DA- TEAMS5.31 DA-NL3.32 DA-NSDSI.33
	Qu		Q-QUERY.34				

Table 3.4: Instruments overview

Legend

LR = Literature review and concept validation
SV = Site visits
P1 = Prototype 1
P2 = Prototype 2
P3 = Prototype 3
P4 = Prototype 4
FE = Final evaluation
Qu = Query

IS = Interview scheme
W = Walkthrough scheme
Q = Questionnaire
DG = Discussion guide
O = Observation scheme
D = Demonstration guide
L = Log book
DA = Document analysis checklist

Note: Each instrument in the above table is available for view via the CD-ROM at the back of this book, see Appendix C

3.4.3 Activities overview

In line with the five tenets influencing the structure of the study, the research activities that took place were selected and carried out based on the results of deliberation between the researchers and participating organizations. Such collaboration was considered to be the most effective way of assuring that the research setting remain authentic as well as relevant and beneficial to the respondents involved. In settings where multiple cycles took place (such as South Africa, Tanzania and Zimbabwe) this also afforded opportunities to jointly learn from experience and revise plans and approaches accordingly. The following descriptions feature highlights from the deliberation process and the resulting plans for activities; additional contextual details are offered for each participating organization in boxed text. The reader will note that the descriptions vary in length and detail. Due to the volume of circuits, the depth of the account given is, in part, determined by the circuit's weight (lighter circuits receive less detailed treatment than heavier ones). Also, rather than repeat information some descriptions refer to similar activities in other circuits, thus reducing redundancy in the text. This section is organized by phase, cycle and circuit, and uses the same instrument codes as those found in Table 3.4 (but because each circuit is discussed individually, the sequence suffix has been omitted from the instrument labels). As previously stated, the circuit overview is located in Appendix A, and the detailed instrument/respondent overview may be found in Appendix B.

Needs and context analysis

The needs and context analysis phase consisted of two cycles. Starting with a cycle of literature review and concept validation activities, this phase concluded with site visits. During site visit cycle, the English version of the original CASCADE program was used as a discussion tool to generate development guidelines.

Literature review and concept validation

As described in Chapter 2, contemporary thinking in the areas of curriculum development, teacher professional development and EPSS contributed significantly to shaping the study, fine-tuning its aims and determining its approach. While the synthesis of literature related to these main themes was initiated at the beginning of the study, this process continued and evolved throughout the course of the research. Early stages of the study were dedicated to two main goals: concept validation and generating design principles. Through literature review and discussions with experts, answers were sought to these main questions:

- Might a tool for computer supported curriculum development be able to address some of the curriculum development and teacher development challenges currently faced by southern African science and mathematics educators?

- If so, how should this endeavor be approached? This question includes:
  Who should be the target audience?
  Where should this tool be made available?
  What aspects of curriculum development should it support?
  When should it be offered to users?

Three groups of respondents contributed to discussions centered around these questions during the first half of the analysis phase. The initial version of CASCADE, created for the SLO, was used as a source of inspiration to focus discussions on the potential value of an EPSS for the desired context. The following text describes who participated in these discussions and how their input was gathered.

Circuit 1: NL1

An expert appraisal was conducted with five professionals (Box 3.3), each having at least three years of experience working in the field of science education in southern Africa. Following one-on-one demonstrations of the Dutch CASCADE program, each expert was individually asked to respond to the proposed notion of creating a tool for the southern African context. Specifically, they were encouraged to describe any opportunities and risks they anticipated; and suggestions for how to proceed were also collected. Such information pertained to the groups who would stand to benefit the most from this kind of an endeavor; what areas of curriculum development should be supported; organizations and individuals that might be able to contribute to its development; and (related to this) recommendations concerning how to go about implementing such a tool. Post demonstration discussions were guided (see D-NL1) by the main questions described in the previous section, but remained basically open in nature, so as to encourage input in other areas that may have been overlooked by the researcher.

> **NL**
> The NL group was comprised of experts from the fields of curriculum development, teacher professional development, EPSS and (science) education in developing countries. These were staff from the University of Twente's Faculty of Educational Science and Technology and/or the Vrije Universiteit Amsterdam's Center for International Cooperation. Various members of this group were involved on four separate occasions (NL1-NL4) throughout the research.

Box 3.3: NL Group

Circuit 2: AMSTIP

> **AMSTIP**
> This group was composed of preservice and inservice teacher educators: staff from the Accelerated Mathematics and Science Teacher Improvement Project in Lesotho.

Box 3.4: AMSTIP Group

An expert appraisal was conducted with five science teacher educators (Box 3.4) working in Lesotho. The AMSTIP group was visiting in the Netherlands and had been informed of the proposed study by participants in the NL1 group. Based on their interest, an expert appraisal was set-up in order to allow the AMSTIP group an opportunity to learn more about the research, while also contributing to the analysis phase of study. Because the discussion tool had not been translated into English, the activity took place through a translated interactive demonstration. The users were presented with the task of planning a formative evaluation of lesson materials, and worked through the program as a group, receiving translations and additional information pertaining to each screen. Following the interactive demonstration, a discussion took place, (see D-AMSTIP) which centered around the aforementioned questions regarding concept validity and suggestions on how to move forward.

Circuit 3: TEAMS1

A third expert appraisal took place in the Netherlands with three visiting colleagues from this science education improvement program in Tanzania (Box 3.5). By this time, however, the CASCADE software had been translated into English, and respondents were able to work through the screens with no need of translation. Again, this group was given the task of planning a formative evaluation of lesson materials with the aid of the computer. They carried out this task with the assistance of the developer, who provided background and supplemental information pertaining to the various components of the program. Afterward, they discussed what they had seen during the demonstration, (see D-TEAMS1) and brainstormed on whether or not a tool like this could be useful for their own context. They also provided recommendations for design and indicated their interest in participating in the future development of this tool.

TEAMS
The TEAMS group consisted of individuals associated with the Tanzanian Teacher Education Assistance in Mathematics and Science program, which is based in the University of Dar es Salaam's Faculty of Education. Various pre and inservice teachers, as well as teacher educators contributed to the TEAMS participation, which occurred on five separate occasions during this study.

Box 3.5: TEAMS Group

Circuit 4: SEITT1

A micro-evaluation took place in the Netherlands; this one also used the English version of the CASCADE software. Five members of the SEITT program staff (Box 3.6) planned formative evaluations with the aid of the CASCADE program. Although participants worked individually, they sat in the same room and discussed their experiences (while working) as a group. Data were collected through the discussions that took place both during and after the hands-on session (DG-SEITT1). This group also considered implications for their own context and provided recommendations for design and the future development of this tool.

SEITT
The SEITT group consisted of individuals associated with the Science Education Inservice Teacher Training program. Based at the University of Zimbabwe, this program trains practicing teachers of science and mathematics to function as resource (or facilitator) teachers in (regionally located) Science and Mathematics Centers (SMCs). The SMCs function as domain-specific TRCs.

Box 3.6: SEITT Group

Site visits with discussion tool

Circuit 5: SAARMSE

> **SAARMSE**
> This group was composed of participants in a three-hour hands-on workshop that was organized during the 1997 SAARMSE (Southern African Association for Research in Mathematics and Science Education) conference in Johannesburg. Informed by the session description in the conference program, participants voluntarily attended the workshop.

Box 3.7: SAARMSE Group

An expert appraisal of the English version of CASCADE took place during this workshop, which was attended by 24 participants, most of whom classified themselves as either teacher educators, experts in the domain of science education in southern Africa, or both (Box 3.7). The main aim of this activity was to gather recommendations on which (if any) groups to target during the design of the system, and to begin to build up a user group profile. In accordance with such information, product specifications for a tool to be used by the target group were also solicited, along with suggestions for development activities. Following a brief introduction to the program and the opportunity to work with the system for two hours, this input was collected through four means: three questionnaires and a group discussion. While everyone participated in the discussion (see DG-SAARMSE), this was not the case for the questionnaires, which were optional for the participants. Many of the participants filled in the (Q-SAARMSEa) context questionnaire in pairs, resulting in 13 completed questionnaires. This instrument asked for general impressions of the CASCADE program, recommendations regarding the design of a similar system for southern African science and mathematics education. About half (n=10) of the participants also filled in the user questionnaire (Q-SAARMSEb), which provided information to help build up a user profile. Only one participant choose to complete the detailed user questionnaire (Q-SAARMSEc), which gathered additional (formative evaluation) feedback on the prototype used during the workshop.

Circuit 6: UB

> **UB**
> The University of Botswana's Inservice Education and Training Program (for science and mathematics teachers) hosted a seminar and a hands-on session with staff and students from the Department of Mathematics and Science Education.

Box 3.8: UB Group

The micro-evaluation held in Gabarone at the University of Botswana was carried out through two activities: a seminar and a workshop. The seminar was attended by approximately 23 staff and students (Box 3.8). Following a demonstration of the CASCADE program, a group discussion took place (see DG-UB), which centered around the perceived usefulness of such a system within the context of Botswana, and ideas regarding future directions for development. The workshop was held with four second-year students who were enrolled in a course on curriculum design. After using CASCADE, they were asked to reflect on the experience through an open interview, based on an existing scheme (IS-UB). The information gathered from this workshop was used to further elaborate a potential user profile.

Circuit 7: TEAMS2
Additional staff from the TEAMS group later participated in an expert appraisal held in Dar es Salaam. In particular, three members of the Department of Curriculum and Teaching participated in one-on-one walkthroughs. In these sessions, participants were given the task of planning a formative evaluation of lesson materials with the aid of the computer. Following the walkthrough process, the participants were interviewed (see IS-TEAMS2). The interviews were open in nature, asking the participants to comment on the program and what (if any) potential they saw for their own context. Because this group saw potential for a future prototype to be used in their inservice education program, the bulk of the time was spent on generating design principles for another version of CASCADE. Also, respondents suggested ways to integrate the design and development of this system into their inservice program in such a fashion as to benefit both the research and the teachers involved.

It should be noted that an additional type of data was collected throughout the study, and particularly during this visit: context information. Although not always explicitly absorbed via any one instrument, site visits proved essential to being able to begin to understand the cultural and contextual realities of the target setting. Particularly because the design of the system was a joint effort on behalf of the researcher and the cooperating sites, such detailed insights were fundamental.

Design, development and formative evaluation of prototypes

Following the analysis phase, prototypes of the CASCADE-SEA support system evolved through the cyclic process of design, development, evaluation and revision: the same basic approach which is, in fact, advocated inside the program itself.

Prototype 1

The first CASCADE-SEA prototype was based on a synthesis of design models for curriculum. In it, the basic elements of analysis, design and evaluation were integrated into one system. During evaluation of the first prototype, expert opinion played a significant role. At this stage, developers were particularly interested in feedback regarding the overall approach (assessing the validity of the conceptual and procedural model upon which this prototype was based).

Circuit 8: DEV1

The development team (Box 3.9) conducted screenings during each cycle of the development phase. During the first screening, the primary developer prepared screenshots (paper print-outs of screen contents) from various pages within the prototype, and including questions or concerns regarding each page (W-DEV1). Two other members of the development team prepared their feedback by writing their comments, concerns, questions and suggestions on the screenshot printouts. All three developers then walked through the stacks as a group, discussing the notations and brainstorming together on ways forward.

DEV
The developer group consisted of four individuals. The primary developer was also the principal researcher in this study. Three mentors (one involved more regularly and more actively than the other two) also contributed to the development of the product as well as the planning and evaluation of research activities.

Box 3.9: DEV Group

Circuit 9: PSU/UGA/USA

The first round of expert appraisal on the CASCADE-SEA prototype took place via visitation to various universities in the USA. During one-on-one sessions in which experts (Box 3.10) walked through the prototype with the developer, the main question respondents (n=13) were asked to answer was, "Given your understanding of the intended context and goals for use of CASCADE-SEA, what would you change in this prototype and why?" (see IS-PSU/UGS/USA). Additionally, experts from Penn State University participated in an interactive demonstration (n=8) and, as a group, debated their comments regarding this same basic question (see D-PSU).

PSU/UGA/USA
This group contains experts in the fields of EPSS and curriculum development, with particular emphasis on the overlapping areas of these two domains. The Universities of Penn State, Georgia and South Alabama each contain departments within their schools of education that have, in the last decade, been actively involved in the arena of computer supported curriculum development.

Box 3.10: PSU/UGA/USA Group

Circuit 10: NL2

The second round of expert appraisal with regard to the first prototype took place at two universities in the Netherlands with experts (see Box 3.3) particularly from the fields of curriculum development and science education improvement in southern Africa. The information gathered via the first round of expert appraisal was used to focus this second round. Consequently, experts (n=19) were asked for their input on those areas of the program that (as determined by the first round of expert appraisal) would be undergoing significant changes. Through one-on-one walkthroughs, this group was asked to comment less in terms of *what* they would change in this prototype, and more in terms of *how* they would achieve certain changes (see W-NL2).

Circuit 11: NL3
Based on the first two expert appraisals of this initial prototype, tentative product specifications were generated. Curriculum development and EPSS experts (n=12) from the NL group were asked to provide feedback on these ideas, and stimulated to elaborate these specifications through four workshop activities. One activity was directed toward generating support for the user in defining the goals and objectives of a lesson series (DG-NL3a); one activity solicited expert ideas on how to help users define the rationale behind their lesson series (DG-NL3b); another activity was designed to collect ideas for metaphors and interactive agents that might provide support throughout the program (DG-NL3c); and the last activity engaged the experts in considering how users might be supported in structuring the content of their lesson series (DG-NL3d). Although group discussions took place, expert suggestions were formally collected through their written remarks on the discussion guides.

Prototype 2
The evaluation circuits carried out on the first the CASCADE-SEA prototype yielded a set of product specifications that were then used to continue development. As the research was being conducted in conjunction with external curriculum and teacher development programs in southern Africa, the temporal priorities of these organizations significantly influenced the developers' decisions regarding the second prototype. In particular, staff from the SEITT (see Box 3.6) and TEAMS (see Box 3.5) groups in Zimbabwe and Tanzania had expressed interest in getting to know the next version of the program. Because teacher workshops were scheduled to take place within a few months (allowing time only for one portion of the prototype to be elaborated), arguments were made for and against the various components that were scheduled for development (please refer to Appendix D for additional detail). After careful consideration, the decision was made to focus on one aspect of the design phase: building individual lessons. The second prototype consisted of a separate tool (it was built outside of the first prototype, with the intention of being integrated at a later date). The "Lesson Builder" as it was called, helped users to create lesson plans and then opened these documents in a word processor so that they might be edited, revised or printed.

Circuit 12: DEV2
During the screening for prototype two, the primary developer prepared a master template of options and support for the lesson plans that the program would help to generate, as well as sample screens from the proposed interface (W-DEV2). Meetings were held individually between the primary developer and the other members of the development team, as well as with four other experts (from the NL group), to reflect on the intended structure of this component. This took place at the beginning of the

prototype cycle and much of the resulting ideas had been integrated into the system before the following two circuits (SEITT2 and TEAMS3) took place.

Circuit 13: SEITT2

Two workshops were held in which the SEITT group learned about the Lesson Builder. A one-day workshop was held at the SMC in Bulawayo, with resource teachers as well as the SMC managers from the region (n=11). This workshop took place in coordination with the installation of the SMC's new link with ZimSciNet (Zimbabwe Science Education Network). The SEITT team had planned to hold an orientation for the teachers and managers, and this opportunity was also taken to explore their reactions to the second CASCADE-SEA prototype. The morning portion of the workshop was used for group discussion of ZimSciNet, computers in general and plans for further implementation of (computer-based) resources that the SMC. In the afternoon, participants were split into two groups. Each group spent half of the afternoon learning about the new computer, modem and photocopier at the SMC, and the other half of the afternoon learning about the Lesson Builder. In the afternoon sessions, the participants were given a demonstration of the Lesson Builder program and then time for group reflection and discussion. A second workshop took place at the SMC on the university campus in Harare. There were 14 attendees, most of whom were resource teachers, plus one representative from the Ministry of Education. Following a demonstration of the prototype, the group was invited to discuss their ideas, reactions and suggestions. Data were collected from all three workshop demonstration discussions (D-SEITT2). Although not formally gathered, talks with the SEITT team also yielded interesting insights and ideas, mostly contributing to the researcher's understanding of the context, and how the CASCADE-SEA program might play a role in it.

Circuit 14: TEAMS3

In Tanzania, the Lesson Builder was tested out in a week-long 'Writer's Workshop' sponsored by the TEAMS project. At this workshop, teachers who had been hand-selected (by their peers) as being particularly motivated and competent, traveled to Dar es Salaam from all over the country with the goal of creating lesson materials (teacher guides). Throughout the week, groups of teachers worked to create lesson materials that could be photocopied and shared among the regions. For everyone in the workshop, a demonstration of the Lesson Builder program was given to all the teachers (n=34) and everyone was encouraged to try the program during the week. Three workstations were set up in the workshop rooms, and assistance was available at all times. Teachers, in small groups and individually, took time to become acquainted with the Lesson Builder program. Most of their comments and feedback were captured through a questionnaire (Q-TEAMS3) distributed at the end of the workshop. During this visit, discussions were also held with TEAMS staff members (DG-TEAMS3), participants were observed using the program (O-TEAMS3), and the resulting documents were analyzed (DA-TEAMS3).

Prototype 3

The third prototype of the CASCADE-SEA program integrated the main elements from the first two prototypes, along with many of the additions and revisions that had been proposed during their evaluation circuits. Further, the CASCADE-SEA user support website was established at this time as well. This version was screened by the developers and then evaluated in nine additional circuits: four expert appraisals and five micro-evaluations.

Circuit 15: DEV3

Together with the integration of the constituent elements of prototypes one and two, one of the most significant new developments in this prototype was the addition of a component dedicated to helping users articulate the rationale behind their work. Although design principles for this element had been considered and pursued since the initial prototype, this was the first version in which those ideas actually took concrete form. For this reason, the rationale component was the focal point of the developer screening during this cycle. As with previous screenings, screenshots were printed, along with a list of the primary developer's main concerns and questions (W-DEV3). Together with two of the other developers, the three walked through the printed screens and discussed how to proceed in fine-tuning this early version of the third prototype. Again, many of the main issues were addressed (through updates and/or additions to the program) before the external evaluations took place.

Circuit 16: SW

The first expert appraisal of prototype three took place during a workshop that was offered at the regional seminar for teacher educators in southern Africa (Box 3.11). After a brief demonstration of the CASCADE-SEA program, the workshop participants were offered the chance to get to know CASCADE-SEA in greater depth during a hands-on session. Participation was limited to the computer capacity of the venue at which this workshop was held. There were six machines available, with two people working together as a team, for a total of 12 participants in the hands-on session. A suggested route for becoming acquainted with CASCADE-SEA was offered, including the recommendation that each team walk through building a rationale profile, creating one lesson plan and setting up an evaluation plan. Participants were then free to explore (1.5 hours) while the researcher/developer

> **SW**
> This group contains experts in the fields of science education in southern Africa and curriculum development in developing countries who participated in the Developing Teacher Leadership for Curriculum Innovation in Science and Mathematics Workshop in Swaziland. This regional seminar for teacher educators in southern Africa was held in October, 1998.

Box 3.11: SW Group

circulated, answering questions and providing assistance where needed. Thereafter, a large group discussion took place in which participants voiced their ideas and opinions about their experiences (DG-SW). This discussion focused on two main topics: the prototype itself (its validity and practicality as perceived by the users) and ways in which it might be implemented within the various contexts of the individual users. A summary of this discussion was presented in a plenary session to the rest of the workshop participants, which spawned further (informal) conversations among interested individuals throughout the rest of the week. As in other circuits, the ongoing discussions about CASCADE-SEA (taking place during the week-long seminar) helped to generate ideas for its future development. However, only the group discussion data (DG-SW), carried out as part of the hands-on session, were formally collected.

Circuit 17: UN

UN
This group contains University of Natal staff working in the Institute for Partnerships between Education and Business. At the time, this group was engaged in establishing a graduate program in curriculum development, and had expressed interest in possibly using CASCADE-SEA in the program.

Box 3.12: UN Group

A brief (half-day) expert appraisal was carried out with three participants from the UN group (3.12) through an interactive demonstration and small group discussion (D-UN). Because this was the main area of interest for these respondents, the data collected in this circuit pertained primarily to suggestions for implementation of CASCADE-SEA.

Circuit 18: SEITT3

A third expert appraisal took place with this prototype, this time in Zimbabwe with colleagues from the SEITT group and 10 others, including representatives from the Ministry of Education, Culture and Sport; Zimbabwe's Curriculum Development Unit, Regional Officers and teachers. After discussion of the ongoing and intended initiatives involving CASCADE-SEA in Zimbabwe, a demonstration of the program was given. Ministry staff then led a discussion on the strengths and weakness of the program, and how it might be of use to those groups represented (D-SEITT3).

Circuit 19: SEITT4

The first micro-evaluation with the third prototype of CASCADE-SEA involved both users and experts. The user groups consisted of fully trained resource teachers (n=14), resource teachers still in training (n=seven) and other interested teachers (n=eight). Five user evaluation sessions were organized in four different regions: two in Harare, one in Mutare, one in Gweru, and one in Bindura. These sessions were organized as full-day workshops, offering an introduction to the main ideas behind CASCADE-SEA, a demonstration of the program, practice sessions (the participants worked hands-on for the bulk of the workshop time) and reflection/coaching.

Depending on the facilities available at each location, respondents worked either individually or in small groups. Data were collected through six methods; instrument names and brief descriptions are given below.

- Q-SEITT4a: At the start of the workshop, participants filled in the preliminary questionnaire, the aim of which was to get an idea of participant (pre-session) computer experiences and skills, their (pre-session) knowledge and experiences in curriculum development and their expectations of the workshop. The questionnaire consisted of open and closed questions.
- L-SEITT4: During the hands-on session, a log was used. After working with a particular component (rationale, design or evaluation) a few questions were answered. Additionally, two other questions were asked every 30 minutes with regard to user motivation and enthusiasm.
- O-SEITT4: Participants were observed while working with the computer, data were collected through this observation scheme.
- DG-SEITT4: Following the hands-on session, a discussion was held in which participants were encouraged to reflect together on the strengths and weaknesses of the CASCADE-SEA program and on their experiences as a whole. The discussion was guided by this set of open questions.
- Q-SEITT4b: A second questionnaire was administered at the end of the workshop, consisting of both open-ended and closed items.
- DA-SEITT4: Finally, the files generated by participants were analyzed. There were two main types: file logs (containing all the selections within the program) indicating the work carried out by users; and the lesson plans that users generated with the aid of the CASCADE-SEA program.

Evaluation data were also collected from SEITT staff, the experts involved in this circuit (n=4). After working individually through the CASCADE-SEA program, these individuals were asked to complete a specially-tailored version of the post-use questionnaire (Q-SEITT4c). They were also interviewed in a one-on-one situation, with the aid of a semi-structured interview scheme (IS-SEITT4). For additional information regarding this cycle, please refer to Van de Put (1999).

Circuit 20: TEAMS4

The second micro-evaluation of prototype three took place in Tanzania, in cooperation with the TEAMS staff. Because developments by this time also indicated that CASCADE-SEA might be useful within pre-service education as well as inservice programs, this circuit included evaluation sessions with pre-service teachers (science education undergraduates at the University of Dar es Salaam), inservice teachers (staff from TRCs), and experts in the fields of science education and curriculum development in Tanzania. The expert group included representatives from the TIE (Tanzania Institute of Education), SESS (Science Education in Secondary Schools), STIP (Science Teachers Improvement Program) and TEAMS. Preliminary informative meetings, full-day workshops and follow-up office meetings were provided opportunities to collect data.

Prior to the hands-on sessions, interviews (IS-TEAMS4) were conducted with four experts from TIE and STIP. Also prior to the workshops, questionnaires were administered to 12 preservice teachers (Q-TEAMS4a), two inservice teachers working at resource centers (Q-TEAMS4b) and to seven TEAMS and SESS staff (Q-TEAMS4c). During the various hands-on sessions, observations were recorded (O-TEAMS4). Participants (n=16) from all groups (except the TRC staff) completed post-workshop questionnaires (Q-TEAMS4d and Q-TEAMS4e). Finally, the lesson plans created during the sessions were analyzed (DA-TEAMS4). For additional information regarding this cycle, please refer to Kafanabo (1999).

Circuit 21: UNESCO1

As previously mentioned, the potential role of the CASCADE-SEA program in pre-service education had been raised on numerous occasions. During the evaluations of the third prototype, researchers decided to explore the possibilities that had been proposed by the potential user groups. The focus of this micro-evaluation was to formatively evaluate the third version of the program with an eye toward using it in pre-service education (Box 3.13). Toward this end, 19 respondents participated in this circuit: 10 student teachers, five TTC lecturers and experts (heads of departments at the TTCs and UNSECO staff). Data were collected through five two-hour workshops with the pre-service teachers, individual working sessions with the lecturers, and interviews with the experts (IS-UNESCO1). During the working sessions with the pre-service teachers and the lecturers, each participant completed an entry questionnaire (Q-UNESCO1a), a log (L-UNESCO1), and a post-use questionnaire (Q-UNESCO1b). The student groups also held a discussion at the end of their sessions (DG-UNESCO1). Further, respondents were observed (O-UNESCO1), and their resulting products (lesson plans) were analyzed (DA-UNESCO1). For additional information regarding this cycle, please refer to Madzima (1999); to learn more about this UNESCO initiative, please see Berg and Vogelaar (1997).

> **UNESCO**
> Within the framework of UNESCO's 'Creating Learning Networks for African Teachers' program, the 'Learning Without Frontiers' initiative had just been launched at the time of this circuit. This program, aimed to foster communication and collaboration between pre-service teachers (and their lecturers), located at Teacher Training Colleges (TTCs). UNESCO staff, preservice teachers and TTC lecturers formed this group, who responded to the notion of using CASCADE-SEA to facilitate group work on the design of curriculum materials.

Box 3.13: UNESCO Group

Circuit 22: PTLC

> **PTLC**
> The Ponhofi Teaching and Learning Center is a TRC attached to Ponhofi Senior Secondary School in rural northern Namibia. The center contains a staff room and 25 Pentium computers.

Box 3.14: PTLC Group

Another micro-evaluation of the third prototype took place in Namibia. User (Box 3.14) feedback was collected through workshop activities during two three-day workshops (one workshop for seven science teachers, and another for 11 non-science teachers). The first day (two hours) featured an introduction to the program, learning how to navigate around CASCADE-SEA and how to use the toolbox that accompanied the program. The second day (three hours) focused specifically on generating lesson plans. And during the third day (three hours), individual opportunities were arranged (to use the system), and remained open to participants in terms of activity selections.

Data were collected through the workshop activities, where eight instruments were used:

- Q-PTLCa: Personal background information and data on lesson preparation and computer user were collected through the entry questionnaire.
- Q-PTLCb: Science teacher reactions to the program were captured through this reflective questionnaire, given at the end of the workshop.
- Q-PTLCc: Non-science teacher reactions to the program were captured through this reflective questionnaire, given at the end of the workshop.
- Q-PTLCd: The Teachers' Attitudes toward Computers (TAC) Form A was completed prior to using CASCADE-SEA.
- Q-PTLCe: The TAC Form B was completed after using CASCADE-SEA.
- O-PTLC: Observations were recorded throughout each workshop through this scheme (and on videotape).
- IS-PTLC: Teachers were interviewed after the last workshop session.
- DG-PTLCA: Focused group discussions took place after the hands-on session.

For additional information regarding this cycle, please refer to Nijhof and Wagenaar (1999).

Circuit 23: RSA1

The fifth micro-evaluation took place in South Africa. This circuit explored the potential of CASCADE-SEA to form a viable solution to some of the issues and challenges brought into play by the introduction of Curriculum 2005 (in which teachers are expected to produce many of their own curriculum materials). A week-long workshop was

> **RSA**
> This group was quite diverse, including teachers from Johannesburg and teacher educators from institutions throughout the country. What this group had in common was their interest in developing materials for Curriculum 2005, and/or helping other teachers to do so themselves.

Box 3.15: RSA Group

held at the University of Witwatersrand in Johannesburg with 30 Biology teachers (Box 3.15). Data were collected toward learning about the potential of CASCADE-SEA for contributing to the professional development of biology teachers using Curriculum 2005. At the start of the workshop, participants completed an entry questionnaire (Q-RSA1a) with background information and questions regarding teacher expectations. During the workshop, each teacher filled in a log (L-RSA1) every 30 minutes, while working with the program, and two other questionnaires capturing their impressions of the program (Q-RSA1b, Q-RSA1c). Group discussion (DG-RSA1) also took place, as did observations of participants using the program (O-RSA1). For additional information regarding this cycle, please refer to Van der Laan (2000).

Circuit 24: RSA2
This second exploration within South Africa was spawned by the workshop activities and word of mouth. Through existing teacher educator networks, news spread of the possibility of a program that could help teachers, and various institutes invited presentation of the program in Stellenbosch, Port Elizabeth, Pretoria and Johannesburg. During the fourth expert appraisal, demonstrations followed by discussions (DG-RSA2), and a questionnaire (Q-RSA2) afforded opportunities to learn more about the validity and practicality of CASCADE-SEA and, in particular, to collect ideas on how to implement the program. In total, 22 respondents shared their thoughts as they considered the overall value of the program, what it might (or not) be able to offer them and how (if at all) such a tool should be implemented.

Prototype 4
Circuit 25: DEV4
In addition to polishing the existing components based on feedback from the previous cycle, the fourth prototype of CASCADE-SEA featured a new component: support for conducting a needs/context analysis. Because it was the first time this component was to be introduced, the analysis component was the center of attention during the developer screening for prototype four. Here too, screenshots were printed, along with a list of the primary developer's main concerns and questions. Each of the other three developers wrote their comments on the printed screens (W-DEV4). Three of the developers then walked through the pages, discussing (in particular) this component's strengths and weaknesses, and how to make improvements. Once the general approach was determined for this area, remaining screening activities concentrated on improving the instruments and tools offered in the analysis component.

Circuit 26: NAM

> **NAM**
> This group consisted of staff from the Ministry of Basic Education and Culture, the National Institute for Educational Development (NIED) and the Presidential Commission on Education, Culture and Training who attended a workshop organized by the Namibian Human Resources Development Program.

Box 3.16: NAM Group

A brief expert appraisal was carried out in Windhoek during a two-hour seminar which featured a brief introduction to CASCADE-SEA, a demonstration of the program and a discussion session (DG-NAM) with all of the (Box 3.16) participants (n=11). An optional questionnaire (Q-NAM) on the topic of possible uses for CASCADE-SEA in Namibia was administered after the seminar, and more than half (n=7) of the participants chose to respond. This circuit yielded very little information in terms of how to improve the program itself. However, activities such as this one were especially useful when considering how to go about implementing the program, and learning about opportunities and complexities that might come into play during such endeavors.

Circuit 27: CET

> **CET**
> This group contained graduate students (practicing teachers) participating in course work at the Center for Education Technology at the University of Zimbabwe in Harare.

Box 3.17: CET Group

In many research settings, local counterparts took the initiative to seek out ways in which research activities could be combined with fruitful activities from which teachers can learn (or vice versa). At the recommendation of the CET's director, the fourth prototype of CASCADE-SEA underwent a tryout through its use in a professional development program: specifically, the inservice training of educational technologists (Box 3.17). After getting to know the software, the participants were asked to analyze CASCADE-SEA from two perspectives: as potential users (they were all practicing teachers and thus could imagine using the program in their own TRCs) and as educational technologists (here, they were encouraged to look critically at this system and the support that it offers). Data were collected from the 11 participants through questionnaires (Q-CETa for science teachers; Q-CETb or non-science teachers), group discussion (DG-CET) and observation (O-CET).

Circuit 28: SEITT5

The SEITT program's fourth (out of four) residential training period for resource teachers (RTs) provided the venue for a second tryout. This two-week session focused on the role of materials in inservice, and how to develop materials. Within this theme, the SEITT team had decided to introduce teachers to the possibility of using CASCADE-SEA. The RTs were exposed to the CASCADE-SEA program in two main ways. First, all teachers attended sessions on making acquaintance with CASCADE-SEA and they worked hands-on with the system (in small groups with mixed levels of computer skills). Then, each subject group (biology, chemistry, physics and mathematics) was also given the opportunity to use CASCADE-SEA and the computer lab to work on their assignment (to create a lesson series). They were free to decide when, if at all, they would use CASCADE-SEA. Teachers were observed during the voluntary sessions (O-SEITT5). They (n=29) also completed a brief questionnaire (Q-SEITT5a) regarding their opinions of the program. During the rest of the week, time and assistance were set aside for this subject teams to work on their materials. At the end of the residential period, all teachers (n=41) were given two evaluation forms; one examined the residential periods a whole, and asked for feedback on course content and delivery; the other one focused on these aspects with specific regard to CASCADE-SEA (Q-SEITT5b). This latter form also asked teachers about their attitudes towards future use of the program. After the close of the residential session, the SEITT team (n=3) met to discuss and reflect on the period including the role of CASCADE-SEA (DG-SEITT5).

Circuit 29: UNESCO2

Having found their first experience with CASCADE-SEA to be a positive one, UNESCO decided to continue such activities. On their own initiative, UNESCO coordinated five two-day workshops aimed at promoting collaboration between educational improvement programs on-going in Zimbabwe, and enhancing the professional development of the participants. The (micro-evaluation) workshops were carried out at five teacher training colleges (Mutare, Belvedere, Masvingo, United College of Education and Gweru Teachers' College) bringing together (a total of 54) participants from UNESCO programs, World Links for Development, Better Schools Project and SEITT. During the workshops, the participants were introduced to the Internet and to the CASCADE-SEA program. At the end of the workshops the participants assessed the applicability of CASCADE-SEA in their own settings, and commented on the changes they would like to have made in CASCADE-SEA before implementing it their own individual situations. Data were collected through observations (O-UNESCO2) an assessment worksheet filled in as the participants used the program (L-UNESCO2A), group discussions after the participants worked with the program (DG-UNESCO2), and a workshop evaluation sheet filled at the end of the two days (Q-UNESCO2).

Circuit 30: SHOMA

SHOMA
Shoma is the name of an educational foundation that uses multi-media technology to provide a three-phase inservice program for educators who are faced with the challenge of implementing outcomes-based education (OBE). The three phases feature satellite, Internet and collaborative lesson planning.

Box 3.18: SHOMA Group

Earlier in this chapter (in section 3.3), a vignette was described in which a series of communications led to the testing of CASCADE-SEA within inservice activities of the Shoma Foundation (Box 3.18). In order to determine if CASCADE-SEA would be able to speak to some of the challenges Shoma had been facing, a tryout took place in cooperation with 16 participants associated with Shoma's Soweto Center. These activities began with observations and videotapes of existing practices related to Shoma's inservice program and, in particular, collaborative lesson development on behalf of the teachers (O-SHOMAa and O-SHOMAb). Further, interviews (IS-SHOMAa) were conducted with staff members to examine ways in which CASCADE-SEA might be integrated into the on-going activities of the Soweto Center. Thereafter, a series of four workshops was carried out over a period of four weeks (one workshop per week). During the workshops, the participants were introduced to the CASCADE-SEA program, with an emphasis on the design component. At the end of the workshops the participants assessed the applicability of CASCADE-SEA in terms of helping them to create their lessons, and commented on the recommendations for improvement, as well. These impressions were collected through a background information questionnaire (Q-SHOMAa); a questionnaire completed after the third workshop (Q-SHOMAb); and a questionnaire completed after the last workshop (Q-SHOMAc). Further, specific insights were collected through an assessment worksheet filled in as the participants used the program (Q-SHOMAd). Documents created during the workshops were analyzed (DA-SHOMA). Finally interviews both with Shoma facilitators (IS-SHOMAb) and participants (IS-SHOMAc) took place after the workshops. For additional information regarding this cycle, please refer to Wuisman (2001).

Semi-summative evaluation
Following the design phase, a final version of the CASCADE-SEA support system was created. This last phase of the study aimed more toward gaining insights regarding the potential impact of the program that had been developed.

Final evaluation
The final version of the program polished up the existing pieces, and added additional functionality to them, based on user input. For example, Kasey (an interactive agent) was elaborated, database functionality was completely re-worked and enhanced, and (additional) supplementary software was integrated into the package.

Circuit 31: TEAMS5

The final version of the CASCADE-SEA program underwent a tryout during another Materials Writers workshop at the University of Dar es Salaam in Tanzania. TEAMS members who were in charge of planning this workshop chose to implement what the coordinator termed his "concentration policy," in terms of working with CASCADE-SEA. This meant that, after a general introduction to the CASCADE-SEA program (with all participants), a small number of materials writers would learn, in depth, how to use the CASCADE-SEA program. These participants would make materials themselves, as well as educate others in this regard.

The small group (consisting of teachers from each of the four subject areas) worked with the program for five full days, with a few breaks for small and large group discussions, which were carefully recorded (DG-TEAMS5). This included plenary reporting sessions in which the CASCADE-SEA group related their experiences to the other writers. During the hands-on sessions, the small group of users was carefully observed (O-TEAMS5) and the documents that they produced were analyzed (DA-TEAMS5). At the end the week, two questionnaires were administered: a general questionnaire for all teachers (n=19) with a small section on their impressions about CASCADE-SEA (Q-TEAMS5a); and a specific questionnaire (Q-TEAMS5b) for the CASCADE-SEA user group (n=5) asking for their opinions regarding the validity, practicality and potential impact of the program.

Circuit 32: NL4

A final expert appraisal was organized and held at the University of Twente during a one-day workshop. Following a brief introduction, participants spent the morning exploring the CASCADE-SEA program in a hands-on session. After lunch, two main activities took place. First, experts were asked to reflect on issues relating to the validity, practicality, and potential impact of the CASCADE-SEA program. They wrote their reactions on nine posters (containing leading questions based on the content of Table 3.1) which were hung about the room. Thereafter, three groups were formed, each with their on individual focus: the *content* group contained primarily curriculum development and teacher professional development experts; the *support* group contained experts on education in developing countries and the *interface* group contained experts from the domains of ICT and EPSS. These groups used the comments on the posters (three thematic posters were given to each group) as input for their discussions centered around two main questions.

- Does CASCADE-SEA have the potential to yield a positive impact in terms of curriculum development and or teacher professional development?
- What recommendations can be made regarding further elaboration and implementation of this system?

They later reported back to the whole group in a plenary session. Through these workshop activities, four data sources were utilized. Participants were observed during the hands-on session and during the small group discussions (O-NL4). The plenary session discussion (DG-NL4) was carefully recorded, in a written form and on videotape. The posters were analyzed separately (DA-NL4), and all participants (n=17) completed a questionnaire that was administered at the end of the day (Q-NL4).

Circuit 33: NSDSI

The director of the PTLC (see box 3.14), together with colleagues from the University of Twente's International Education Office, designed a tailor-made training program for facilitator teachers from Namibia (Box 3.19). This program was offered at the University of Twente, and one of the courses was specifically developed to introduce teachers to CASCADE-SEA. This provided an outstanding opportunity to observe how the target group worked with the system over a longer period of time (one month). Throughout the course, opportunities were sought to combine research goals with meaningful activities for the participants. Data were collected through:

> **NSDSI**
> This group consisted of nine participants in the Namibian School Development and School Improvement program, held at the University of Twente.

Box 3.19: NSDSI Group

- Careful notation of classroom discussions (DG-NSDSI);
- Observation of participants when working hands-on with CASCADE-SEA (O-NSDSI);
- Log books which were filled after every class meeting (L-NSDSI);
- Analysis of documents created by participants (analysis and evaluation plans, lesson plans, etc.), in particular the final assignments which asked for critical reflection on the month's activities (DA-NSDSI); and
- A questionnaire which was completed at the very end of the course (Q-NSDSI).

Exploratory Query

Circuit 34: QUERY

As described in section 3.4.1, an exploratory query took place during the study's semi-summative evaluation phase. This activity served two functions. To a lesser extent, the query contributed to answering the main research question by collecting information about the program's validity, practicality and impact potential. The main question behind this aspect of the query was, *"What are participant perceptions regarding the strengths and weaknesses of the CASCADE-SEA program, and why?"* In addition, the query explored potential uses for CASCADE-SEA (or a variation thereof) toward other purposes than originally intended (i.e.: in other subject areas, grade levels, parts of the world, languages etc.). Such information was thought to be useful toward: collecting data upon which to base the recommendations for future use; generating contacts and initiatives that might be useful for future collaboration; and gathering insights to be used in a research proposal for expanding this line of inquiry. The main question behind this aspect of the query was, *"In what ways (if any) would participants be interested in working with CASCADE-SEA, or a tailored version hereof, and why?"*

Various groups of experts and users who had previously expressed interest and ideas regarding future research related to CASCADE-SEA signed up to participate in the query during site visits, conferences and via informal meetings (Box 3.20). Invitations to participate in the query were sent to all 153 individuals via e-mail. Of these invitations, 51 messages encountered (some form of) delivery failures; 41 received no response; and 61 were accepted (the recipient replied to the invitation by sending an email to the researcher, confirming interest to participate).

QUERY
This heterogeneous group consisted of individuals who indicated interest in participating in the international exploratory query. Participants classified themselves as one or more of the following: teachers, preservice teacher educators, inservice teacher educators, curriculum developers or other.

Box 3.20: QUERY Group

Query materials were then sent to the 61 recipients via post; packages were structured to provide all necessary information to complete the query. In addition to a courtesy card, the package contained: (1) a brief (one-page) letter to the participant explaining how to complete the query (originally termed, survey); (2) a CD-ROM with various related software, including the CASCADE-SEA program; (3) an instruction sheet for installing the CASCADE-SEA program; (4) a printed copy of the query questionnaire (Q-QUERY) and; (5) a self-addressed envelope (for returning the query questionnaire). Within four months, 16 of the 61 individuals responded to the query by either sending the printed copy of the questionnaire, completing an on-line version of the same form or e-mailing an electronic copy of their completed questionnaire. Thereafter, a reminder e-mail was sent to the remaining 45 participants (along with encouragement to pass the package along to any interested colleagues). An additional 18 responses were then submitted, for a total of 34 query participants.

While this activity also contributed to the semi-summative evaluation of CASCADE-SEA, the main aim was to explore potential uses for the program outside the realm of original intentions. As such, it was designed to extract useful and interesting ideas for future development from interested parties. With a focus on the desire for good ideas (and *not* for generalizeable data, per se), no attempt made to achieve representativeness of any given population. For this reason, the participant variation (in countries, professions and organizations represented) as well as the response rate of 56% (calculation is based on the 34 reactions to the 61 packages that were actually sent out) was viewed to be sufficient for the purpose mentioned. Further, toward the assessment of CASCADE-SEA's quality, only relevant data were included. For example, since few of the participants belonged to the target group or were familiar with the target setting, no query data related to congruence (a sub-aspect of practicality) were used toward the semi-summative evaluation.

3.5 Data analysis

3.5.1 Process and techniques

The development research approach, together with the foundational tenets, influenced decisions made regarding data analysis procedures. To maximize the potential of the study's emergent design, data analyses were conducted after each circuit so as to inform the following ones (and again at the end of the study). Such repeated interim analysis is referred to as 'sequential analysis' by Miles and Huberman (1994, p. 84), who comment as follows on the strength and weaknesses of this approach: " Their [interim analyses'] strength is their exploratory, summarizing, sense-making character. Their potential weaknesses are superficiality, premature closure, and faulty data. These weaknesses may be avoided through intelligent critique from skeptical colleagues, feeding back into subsequent waves of data collection." In this study, the means used to conduct sequential analyses encouraged such critique, as illustrated below.

What	Who	How
▪ Quantitative data were collected and used to identify general trends and themes ▪ Qualitative data were collected and used to deepen understanding of trends and themes by examining specific, often more personal insights	Data analysis was conducted by the researcher, together (where appropriate) with: ▪ Research assistants (n=8) ▪ Developer group ▪ Critical friends	Depending of the type of data collected, one or more of the following techniques were used: ▪ Translation/transcription ▪ Summarization of data ▪ Calculation of mean, median, mode and standard deviation ▪ Data coding and pattern coding ▪ Interim documentation ▪ Site visit reporting ▪ Case analysis meetings

Box 3.21: Data analysis processes and techniques

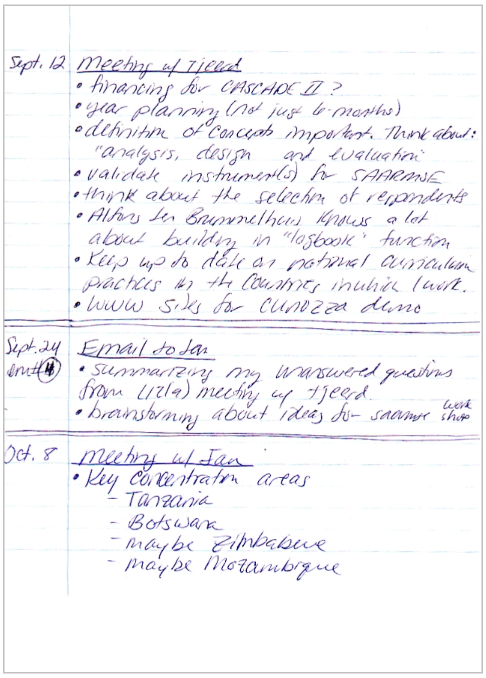
The processes and techniques used for each circuit's data analysis varied along with the nature and scope of the circuit activities (and the resulting yield in data types). Box 3.21 (above) displays an overview of the processes and techniques used throughout the study. It shows that both quantitative and qualitative data were collected. Further, it illustrates that analysis of the data was often conducted in cooperation with other individuals. Some of the analysis techniques (e.g. case analysis meetings) naturally invited critical friends to help understand (or confirm how to interpret) what was happening. In other instances (wherever considered efficient and effective), the researcher engaged the assistance of one or more colleagues.

As previously mentioned, data were analyzed twice: immediately after the data collection activities took place (to inform the following decisions), and at the end of the entire study (to gain an overall perspective). Both procedures involved the techniques listed in Box 3.21. Data were translated (where necessary) and then transcribed into text files; and these files were then summarized into separate text files. Depending on the nature of the data, these summaries related to either quantifiable information (mean, median, mode and standard deviation) or qualitative codes (tags or labels for assigning units of meaning to descriptive or inferential information) and patterns (collections of codes identifying emergent themes, configurations or explanations). Please refer to Miles and Huberman (1994) for detailed descriptions of these techniques.

Data were analyzed both deductively (classified according existing schemes) and inductively (through recognition of emergent patterns). The (quantitative and qualitative) data summaries were chunked according to their relationship to the quality aspects discussed at the beginning of this chapter (please refer to Table 3.1). That is, they were first clustered by main evaluation question (pertaining primarily to validity, practicality or impact potential) and then by sub-question (for validity, those were: state-of-the-art knowledge and internal consistency; for practicality those were: instrumentality, congruence and cost; for impact potential those were: better quality materials and enhances professional development). Each summary contained a table with separate sections for content, support and interface issues. Within the tables, each item was color-coded for its relationship to various parts of the CASCADE-SEA program or study. These summaries, as well as other interim documents and site visit reports helped to put the data collection activities into perspective. Further, they provided discussion tools for case analysis meetings which took place regularly among the developer group. (Please refer to Chapter 5 for additional information regarding the data summaries.)

In addition to the data analysis techniques mentioned above, the researcher also used photographs, videotapes, developer logbooks and field notebooks during data analysis. Although the instruments described in section 3.4 provided the bulk of the data, revisiting these sources was extremely useful in reconstruction of events, and interpreting data in the proper context. Samples of these sources are shown in Figures 3.2, 3.3, 3.4 and 3.5 (opposite page).

Figure 3.2: Photograph from first Tanzanian workshop



Sept. 12 Meeting w/ Tjeerd
• financing for CASCADE II ?
• year planning (not just 6-months)
• definition of concepts important. Think about: "analysis, design and evaluation"
• validate instrument(s) for SAARMSE
• think about the selection of respondents
• Alfons ten Brummelhuis knows a lot about building in "logbook" function
• Keep up to date on national curriculum practices in the countries in which I work.
• WWW sites for Cunozza demo

Sept. 24 Email to Jan
• summarizing my unanswered questions from (12/9) meeting w/ Tjeerd.
• brainstorming about ideas for saarmse workshop

Oct. 8 Meeting w/ Jan
• Key concentration areas
- Tanzania
- Botswana
- maybe Zimbabwe
- maybe Mozambique

Figure 3.3: Page from developer log

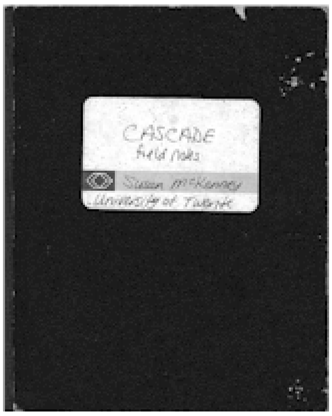


Figure 3.4: Field notebook used during CASCADE-SEA study

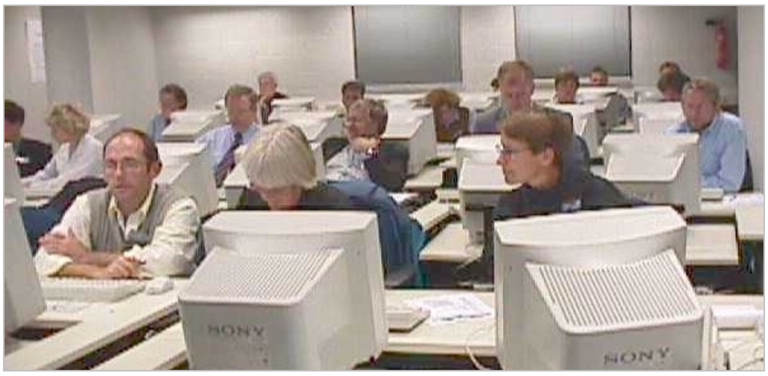


Figure 3.5: Footage from last workshop in the Netherlands

3.5.2 Multiple roles

A responsible discussion of the data analysis processes would not be complete without drawing attention to the many roles played by the main researcher. The study was both challenged and enriched by the fact that the main researcher was (simultaneously) also the designer, developer, programmer, and (in most cases) evaluator of the CASCADE-SEA program. Further, it was the same individual who (usually) served as the facilitator of workshops and activities in which participants became acquainted with the software.

This conscious decision to 'wear many hats' was based primarily on the perceived benefits associated with a constant overview of developments and their implications. For example, decisions could be weighed more easily from various perspectives and they could be made better on-the-fly. To illustrate, a constant overview of the various aspects of the study (research history, future directions, developer intentions, etc.) allowed the researcher/evaluator to network toward additional testing situations, as sampling/data collection leads could be followed (more) immediately. Further, such an overview was perceived to be extremely efficient and therefore allowed for smooth transition of insights from one 'hat' to the other. For example, some circuit data contributed to improving the practicality and impact potential of the CASCADE-SEA tool by helping the developer hat to understand the context better. This was even the case in situations where direct prototype feedback was minimal, non-committal or (for other reasons) weak - which would have rendered the findings less relevant for the evaluator hat, and might otherwise have gone unused.

Additionally, it allowed for easy switching between hats, such as when the developer hat might interrupt the evaluator hat to continue or deepen a particular line of questioning (this was especially useful in generating new ideas for prototypes). Whereas the evaluator hat might be more concerned with answering a question like, "What aspects would should be changed in the program and why?" the developer hat might respond to an answer such as, "the various parts of the program should be more linked with each other" by asking for suggestions on how to realize that. Alternatively, the designer hat might be influenced by the actions of the facilitator hat. For example, when the facilitator hat notes that certain (workshop) activities might be well-supplemented by printed materials, the designer hat might immediately begin musing on how to shape them and integrate them with the program (programmer hat).

Cognizant of the threats to the study associated with the decision to place the main researcher in so many roles simultaneously, two main precautions were taken to mitigate them: vigilant segregation of data and subjective inferences; and (three forms of) triangulation. Recording impressions through photographs, audio- and videotapes, developer logbooks and field notebooks facilitated the segregation of data and subjective inferences. Fieldnotes and (audio- and video-) tapes included as much verbatim conversation as possible, so as to reduce possible influences from the researcher. Fieldnotes also included memos regarding context, to help interpret information later; these were *not* interspersed with the data itself. Contextual understanding was also supported by the use of videotapes and photographs. Comments, inferences and judgements were kept separate from data collection instruments. Similarly, internal documents/site visit reports were reviewed separately from the data, as they contained hunches and personal explanations of local theories or interpretation of events.

Secondly, as mentioned earlier in this chapter, three forms of triangulation (data, method and investigator) were achieved; this also strengthened the data analysis process. Varying the sources of data (time acquired, locations of activities and people involved) yielded multiple opportunities to examine similar/same phenomena. This mitigated the threat of introducing random errors due to drawing premature conclusions based on unique instances. Differing methods of data collection (e.g. through interviews, observations, etc.) resulted in multiple data summaries that were analyzed and then cross-checked, to validate the conclusions drawn per circuit. Where possible, data analysis and interpretation was conducted together with other individuals (research assistants, developer group and critical friends), to reduce the threat of (any) personal bias. This also reduced the chance of systematic error. While the last chapter in this book discusses the implications of this decision to 'wear many hats' in hindsight, Chapter 4 discusses the combined outputs of these many 'hats' by specifying design principles that shaped the CASCADE-SEA program, and describing the software itself.

3.5.3 Research website

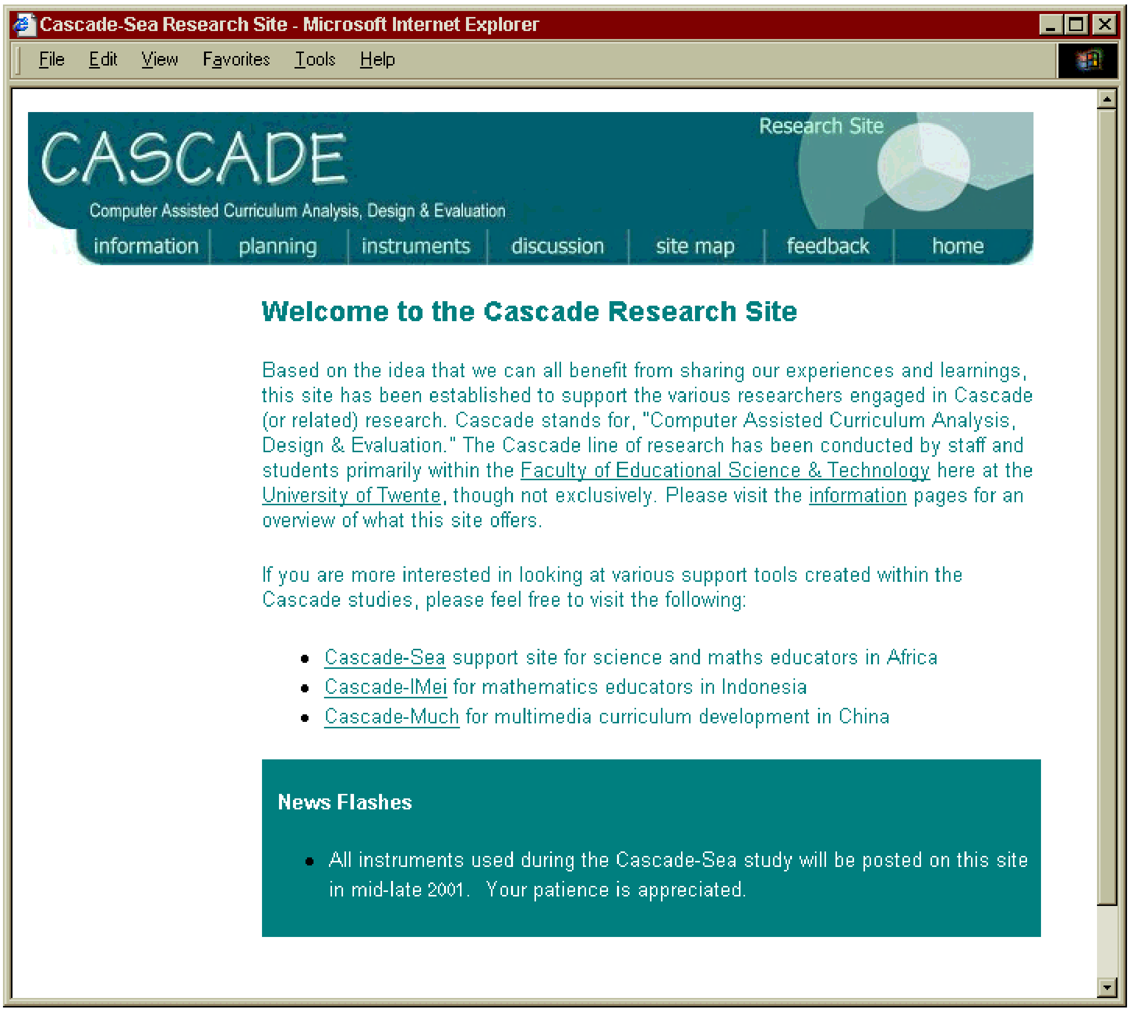


Figure 3.6 Research Website at Http://projects.edte.utwente.nl/cascade/seastudy/

Although it relates to other aspects of the study as well, an additional mechanism was established that bears mention when considering the data analysis processes: a research website. This Internet website was hosted on a server at the University of Twente, and maintained by the researcher. Because some circuit activities were carried out by different individuals (often working simultaneously, in different countries), this site was established to facilitate communication and inter-researcher/assistant learning. Research plans (e.g. data analysis procedures), tools (e.g. hands-on workshop agendas), instruments (e.g. questionnaires) and reports were posted to allow those involved to benefit from the experiences of others. Figure 3.6 (previous page) offers a glimpse of the site through a screen shot from the home page. This site is separate from (though linked to) the CASCADE-SEA support site designed for users of the program. This, and other aspects of the program are described in detail in the following chapter.

Chapter 4

Principled design: the evolution of CASCADE-SEA

The research described in this book was carried out via the analysis, design, development, evaluation and revision of four prototypes and a final version of the CASCADE-SEA *program. Whereas Chapter 5 presents the data collected during the various cycles of this study, this chapter describes the research outcomes in terms of the products generated. First, the tenets, guidelines and specifications that shaped the* CASCADE-SEA *program are presented. Thereafter, the four prototypes are briefly described. The remainder (and bulk) of this chapter then discusses the final version of the program, including the related website. Throughout all five sections, attention is given to the three perspectives of program content, support and interface.*

Walker (1990) recommends that a 'platform of ideas' for curriculum development can be extremely useful in helping developers to make the thousands of necessary decisions as they shape their design. The design and development of the CASCADE-SEA program was also structured by such a platform, containing ideas of varying degrees of abstraction. As previously mentioned, *foundational tenets* were formulated in accordance with the overall aims of this study; toward creating the CASCADE-SEA tool, the implications (of these tenets) for design were examined. Further, related theories and models (pertaining to curriculum development in general and the creation of exemplary lesson materials in particular) were studied to generate *development guidelines* for creating the desired program. Finally, by reflecting on the foundational tenets and the development guidelines, together, *product specifications* for the actual CASCADE-SEA tool were elicited. This section discusses the CASCADE-SEA platform of ideas, considering these three layers of assembly.

Derived from a review of relevant literature, five tenets that influenced the structure of this study were introduced in Chapter 2. Given that this study explores certain aspects of curriculum development and teacher development *through* the creation of a tool for curriculum development and teacher development, it is then consistent that these tenets affect both the CASCADE-SEA investigation and the CASCADE-SEA product. The manner in which they impacted the research approach was addressed in Chapter 3. The following text discusses the implications of these tenets for the general design of the CASCADE-SEA tool itself.

4.1 Foundational tenets

4.1.1 Local relevance

A basic creed for the design of instruction is to consider the perspective of the learner, and take that as a starting point. The same holds true for the design of a support system: an understanding of the user perspective must be integrated into the design itself. With regard to a program aiming to support the creation of exemplary lesson materials in the domain of secondary level science and mathematics education in southern Africa, a number of user considerations bear mention. These relate to pedagogy, teaching qualifications and computer literacy.

Within the target setting, current pedagogical practice is often characterized as teacher-centered (as mentioned in Chapter 1). Yet, most countries in this region of the world are engaged in curricular reform efforts that, in addition to other innovations, include a move toward more learner-centered teaching and learning. While such changes may take place rather quickly in terms of policy revision, changes in classroom practice usually occur gradually, yielding great variation among teachers and curriculum developers in the meantime (as new ideas begin to take root). Therefore, the pedagogically related aspects of the CASCADE-SEA system should accommodate various types of users (at various stages of curriculum adoption) while refraining from peddling any particular ideology.

Curriculum materials have the potential to offer significant support to teachers. In the case of un(der) qualified teachers, textbooks and exemplary materials often function as a life-preserver, being the only source of guidance and support readily available. The CASCADE-SEA system should acknowledge this reality, and support its users in creating materials that provide a carefully crafted blend of guidance for such teachers. As described in Chapter 2, research has identified characteristics of exemplary materials that render them effective. Based on these insights, the materials designer should be encouraged to consider the integration of basic teaching skills, subject matter content, teaching and learning methods as well as assessment ideas into the teacher guides made with CASCADE-SEA.

Due to the relatively recent trend of introducing computers into TRCs in developing countries, only a small percentage of the target user group may be expected to have experience using such facilities. For this reason, the CASCADE-SEA program should provide an environment that takes this fact into consideration. At the same time, designers should be cautious not to confuse the aim of the CASCADE-SEA system with the (likely) need for fostering computing skills. Instead, an attempt should be made to strike the most effective and efficient balance between the conceptual and procedural support offered (relating to creating good quality materials) and the operational support needed (in terms of working with the program). Toward this goal, the system should be both easy to learn and safe. CASCADE-SEA should evidence scaffolding by integrating support (reducing the effort needed to become acquainted with the program) into the core activities and falling away when no longer needed. At the same time, it should provide a safe environment where users need not fear the possibility of destroying (parts of) the system, the loss of data nor the irreversibility of their actions.

4.1.2 Collaboration

As previously stated, design and development activities should be conducted in collaboration *with* and not *for* those involved. This not only implies how the system should be developed (as discussed in Chapter 3), but also the kinds of collaboration that CASCADE-SEA should encourage between its users. In fact, this program should support such cooperation not only among the intended users (materials developers), but also with those teachers who will ultimately use the materials created (regular teachers).

First, appropriate activities must be selected and structured in such a way as to foster collaboration among the materials developers, taking into account the goals of promoting curriculum development and teacher development (and not simply allowing collaboration to become a goal itself). Second, the program should provide sufficient opportunity and support for the participatory design of lesson materials. That is, the involvement of the (regular) teachers who will ultimately use the materials should (where practical and valuable) be encouraged. Finally, the exact needs, wishes and preferences of the CASCADE-SEA user group (in terms of how to go about developing materials) is likely to vary. This implies that system designers must create flexibility for ways of using the program. In particular, users should have large degrees of freedom to choose how, when, and to what extent support is utilized. Ultimately, it is not the computer, but those who actually implement the program (facilitators and teachers within the TRCs) who should have definitive control of the materials development process.

4.1.3 Authenticity

The use of ICT in education is intended as a mechanism through which certain activities may take place, not an innovation or a goal worth pursuing on its own merits. In the case of CASCADE-SEA, designers should thus focus on the notion that they are creating a tool, which is to be used within TRCs (as opposed to an independent innovation). Both the activities inside the program and the resulting products should have a distinct link with ongoing (TRC) activities. In fact, CASCADE-SEA should be designed in a way that allows for (the closest approximation of) seamless integration with curriculum development activities. It should help do that which is already a priority: create low-cost, easily reproducible materials. And recommendations on how to do this (ranging from suggestions for front-end analysis activities to strategies for implementation of the materials created with the aid of CASCADE-SEA) should be based on familiar practices. In short, rather than coercing the users to bear the evangelical burden of promoting yet another educational improvement initiative, this program should lighten the existing load and make the user's task easier.

4.1.4 Mutual benefit

With the main goal of supporting the synergy between curriculum development and teacher development, the CASCADE-SEA system should promote practical and useful curriculum development activities that are, simultaneously, viable forms of professional development. It should offer users the chance to work at their own pace, and the opportunity to decide for themselves how detailed their curriculum development project(s) should be. It should offer users a range of useful activities, but leave the decision in their own hands as to how much time and effort to spend on certain steps, which areas to concentrate on, and which ones to omit. In this way, less experienced users are offered guidance plus 'room to grow' while more experienced users are not bogged down by imposed norms.

4.1.5 Continuous (re)analysis

The importance of considering, continuously and carefully, the target setting and the aims of one's endeavors is a postulate upon which this study was designed. In terms of designing the CASCADE-SEA system, the program should support and encourage users to articulate, reflect on and (if appropriate) revise those ideas that are driving forces behind the creation of their exemplary lesson materials.

These foundational tenets provided a framework within which design options could be generated and decisions could be made. Yet, however valuable, such a philosophical perspective *on its own* remains insufficient fodder for building the actual program that is desired. Much must also be considered in terms of the content to address, the support to offer and how it should all be packaged: the interface. Guidelines for these elements are discussed in the following section.

4.2 Development guidelines

While many of the guidelines used to structure the CASCADE-SEA program were derived from literature, still others were the result of experience and reflection. That is, such development guidelines often emerged, or became better articulated, as a result of the prototyping activities themselves. In an effort to summarize the development guidelines that shaped the CASCADE-SEA program, this section is organized by the main areas of content, support and interface. But it should be recognized that such a structure may distract from illustration of the evolutionary nature of the development guidelines. This aspect may be better understood through the prototype descriptions in section 4.2 and the evaluation results described in Chapter 5.

4.2.1 Content

As discussed in Chapter 2, curriculum planning models abound, and vary greatly. Throughout this study, one challenge has been to identify and scrutinize those models that possess an intrinsic connection to the (aforementioned) tenets that guided the study. By so doing, developers hoped to shape a conceptual framework for designing a valid and practical tool possessing the potential to impact the performance of (resource) teachers in the creation of exemplary lesson materials.

In her review of design methodology, approaches and models, Visscher-Voerman (1999) begins by examining two basic schools of thought that have influenced design thinking. She looks at Simon's work (1969) and the underlying assumption that prescribing one general design approach can help solve a range of different problems. In contrast, Schön's views (1983) emphasize that the unique input of the individual designer and the ill-defined nature of most design tasks contribute to a methodology which is much more descriptive in nature. Because the CASCADE-SEA program was intended for use by a fairly homogeneous group (secondary level science and mathematics resource teachers making exemplary teacher guides), certain elements of a 'Simon-like' systematic decomposition seem useful in providing the users with clear, structured support for their task. However, the underlying goals of stimulating reflection (on behalf of the individual designer) and fostering a sensitivity for the target setting call for such ideas to be tempered by an appreciation for the artistry of design. So, the CASCADE-SEA system should demonstrate a thoughtful blend of both prescriptive and descriptive approaches to curriculum development. To achieve this, developers turned to systematic models of curriculum and instructional design (relevant for making teaching materials) for inspiration regarding the main steps to include, in terms of both content and sequencing. In addition, models highlighting reflection and deliberation offered guidance on how to carry out those steps.

Although educators have been designing instruction since the days of Plato, the field of curriculum design in terms of being a systematic process for improving instruction gained its first real momentum in the 1920s (Bobbitt, 1924). As study in this field evolved, so did the need for theory building. Aiding in conceptualization and communication, instructional development models began to take shape. Various scholars have studied such models through (often extensive) reviews, including Andrews and Goodson, 1980; Salisbury, 1990; Edmonds, Branch and Mukherjee, 1994. In their survey of instructional development models, Gustafson and Branch (1997) conclude that the overall instructional design process (as represented in these types of models) has not changed significantly throughout the last four decades.

Gustafson and Branch (1997) also present a taxonomy of instructional models based on the underlying assumptions about the conditions under which development and implementation should/will occur, distinguishing between classroom orientation, product orientation and system (or organizational) orientation related to selected characteristics. But they indicate that most models are shaped around certain core elements of the instructional design process; these are illustrated in Figure 4.1.

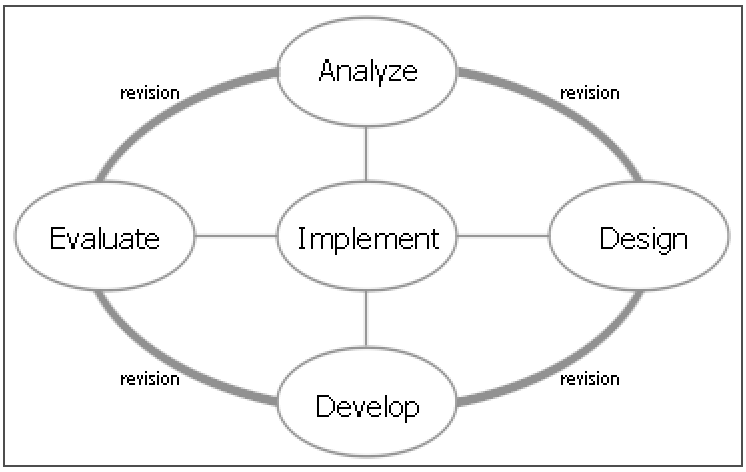


Figure 4.1: Core elements of instructional development (Gustafson & Branch, 1997)

Taking these ideas as a starting point, it may be said that the core components of analysis, design, development, implementation, evaluation and revision should be carried over into a conceptual framework for the CASCADE-SEA system. Further, guidelines describing how to operationalize these elements should be rooted in the underlying assumptions about the desired output, as well as the conditions under which the design and development will take place. So, rather than remaining generic in nature, these elements should depict the specific processes related to creating exemplary teacher guides for secondary level science and mathematics teachers in Southern Africa, as the following text describes.

Analysis

While most instructional design models portray some kind of front-end analysis as an essential ingredient, variation does exist among them in terms of how much analysis is necessary, and what the main focus should be. Some models tend to concentrate primarily on understanding certain specific inputs related to the problem, such as learner characteristics (Branson, 1975; Heinich, Molenda, Russel & Smaldino, 1996; Kaufman, 1979). Nevertheless, the majority of more recent models also emphasize an understanding of the learning environment/context (Dick & Carey, 1996; Kaufman, Stakenas, Wagner & Mayer, 1981; Kessels, 1993). More linear models usually break apart such activities into distinct steps or phases, each with their own recommendations on how to analyze particular elements and use those findings to inform the next steps (National Special Media Institute, 1971; Romizowski, 1981). In contrast, are organically oriented models which integrate continuous (re)analysis into cycles of development activities (Moonen, 1996; Nieveen, 1997).

Tessmer and Harris (1990, 1992) take a holistic view and advocate the value of designing instruction based on an environmental analysis. They recommend a proactive, iterative approach toward generating a profile of the instructional situation, which may be used to design specific (instructional) products. In particular, they emphasize the need to understand both the instructional environment (teacher and learner roles, physical aspects, purpose/use of instruction) and the support environment (surrounding aspects relating to management and dissemination). The appreciation for context sensitive design, combined with an emphasis on implementation issues through its cyclic approach, illustrate a significant degree of alignment with the foundational tenets that guided this study. Therefore, their ideas regarding environmental analysis should be consulted as a source of inspiration for considering the specific content of the analysis component within the CASCADE-SEA program. The following paragraphs examine ways to integrate such ideas in the proposed system.

To create good quality curriculum materials, the developers must embark from a working understanding of the kind(s) of materials that are needed as well as the context in which the materials will be used. While some facilitator teachers at TRCs may, by nature of their profession, have insights in these areas, it would not be prudent to assume that all members of the target user group possess such knowledge. Therefore, CASCADE-SEA should offer the user the opportunity to consider the kinds of materials needed and the contextual factors that should be contemplated during their design. In addition, the system should provide support for those who would like to deepen their understanding or confirm their assumptions by conducting a needs and context (or, environmental) analysis.

Towards consideration of the kinds of materials needed within a given context, Chapter 2 discussed the fact that research has shown exemplary materials to be extremely useful when they contain procedural specifications. Van den Akker (1988) suggests that these should be geared toward helping the teacher to focus on issues of lesson preparation, subject matter content, teaching and learning methods and assessment. With these four areas in mind, CASCADE-SEA should assist the user in determining which ones should receive greater and lesser attention, given the specific needs and preferences of those who will ultimately use a particular set of materials. In so doing, the notion of various curriculum representations (as discussed in Chapter 2) provides some guidance. Materials developers should be encouraged to identify (any) gaps between various curriculum representations, in an effort to ascertain which, if any, links in the curriculum implementation chain may be in need of reinforcement. This implies that CASCADE-SEA should support the user in learning about the ideal curriculum intentions, the way(s) such intentions are perceived by various stakeholders, and how they actually take shape in the classroom.

So they may learn more about these issues within a given setting, the computer should help users structure a line of inquiry. This implies that CASCADE-SEA should assist the user in formulating guiding questions, considering how those questions may be answered, and preparing mechanisms through which those answers may be obtained. In essence, the computer should provide support throughout a small research cycle. In many ways, such a process shares similarities with the activities that are central to (formative) evaluation. Scriven (1994) refers to formative evaluation as a front-end activity in his description of "preformative" evaluation: formative evaluation of a proposal or even the concepts underlying a proposal. Although the types of questions being asked in a needs/context analysis generally vary significantly from those leading an evaluation, both processes feature the an information-gathering approach and an orientation toward deeper understanding of that which is being examined.

Given the similarities between analysis activities and evaluation endeavors, it may be concluded that, to a limited extent, development guidelines for this phase of the program may also be derived from the body of knowledge relating to evaluation. In addition to literature and experience, the original CASCADE program, developed to support formative evaluation activities for the SLO, should also be consulted for development guidelines. The CASCADE program maps the task at hand into four main phases (with sub-phases): preparation, data gathering, data analysis and reporting (Nieveen, 1997). These ideas, together with insights from the previously-mentioned literature insinuate that CASCADE-SEA should: articulate procedures and steps in conducting analysis; emphasize understanding of the target environment; help identify gaps between curricular representations; and do this through a clear structure. Toward that end, the following list identifies the main content that should be included in the analysis portion of the CASCADE-SEA program:

- *Initial orientation:* What do I want to know?
- *Selection of strategies:* What kinds of settings and actors will be able to provide the information I need?
- *Determination of methods:* What are the most appropriate activities I can undertake to obtain that information?
- *Planning:* What opportunities and constraints should influence the way I carry out these activities?
- *Creation of instruments:* How can I best capture the kinds of data I need?
- *Respondents:* How should I select and approach people?
- *Collecting data:* How do I actually carry out these activities?
- *Interpreting data:* How do I make sense of all the data gathered?
- *Drawing conclusions:* How will I use this information?

Ultimately, users should exit this area of CASCADE-SEA with a well-articulated understanding of the environment in which their materials are to be used. This includes knowing what sorts of materials are desired, as well as which contextual factors should be taken into consideration during their design.

Design

Once materials designers possess a clear sense of what they would like to create, CASCADE-SEA should aid the users in reaching those aim(s). This means that the program should, as much as possible, help the users to stay in touch with their intentions and, where necessary, revise or refine them. In terms of creating exemplary teaching materials, designers will need to bear in mind two types of intentions: (1) the overall aims of their materials in terms of providing support to the teachers; and (2) the learner-oriented goals and objectives associated with the activities and events suggested in their teacher guides. Whereas determination of the overall aims is a task to be executed during an initial orientation (analysis) phase, the specification of learner-oriented goals and objectives may be considered part of the design process, in this case.

Because CASCADE-SEA intends to support the creation of teacher guides (usually consisting of multiple teaching and learning sessions), it would be advantageous if the system assists the users in distinguishing between goals for a lesson series (or module) and objectives for a particular lesson (or learning event). Most models for the design of instruction recommend an early orientation toward articulating specific goals (c.f. Dick & Carey, 1996; Heinich, et al, 1996; National Special Media Institute, 1971) and some go as far as to specify when and how such goals should be clustered (Kemp, Morrison & Ross, 1994; Posner & Rudnitsky, 1986) while others explicate that attention (also) be given to sequencing (Diamond, 1989; Posner & Rudnitsky, 1986; Romiszowski, 1981). Relevant, selected insights from these sources should be applied to the design of the CASCADE-SEA program.

In terms of setting goals and structuring the related content, much of what teachers and materials designers in southern Africa do tends to be determined by that which is prescribed in national syllabi or available textbooks. Despite this fact, or perhaps even because of it, the CASCADE-SEA support system should stimulate users to consider various ways to cluster and sequence the goals and related content in their lesson series. Encouraging users to critically examine that which may otherwise be subject to blind acceptance exemplifies responsible curriculum development, and may also be viewed as a viable form of professional development. Even if they choose to ignore this (and/or other) part(s) of the program, the exposure to such ideas possesses merit of its own. Further, such an approach places the responsibility for determining *how* to use the program in the hands of those who should be making such decisions in the first place: the implementers and users of CASCADE-SEA.

Development

Materials developers, knowing the lessons for which they would like to develop teacher guides, should receive support from CASCADE-SEA in developing these plans. Much has been written on the essential aspects of sound lesson design in general (Ben-Peretz, 1975; Briggs, Gustafson, & Tillman, 1991; Brophy & Alleman, 1991; Clandinin & Connelly, 1992; Dick & Carey, 1996) and exemplary lesson materials in particular (Ball & Cohen, 1996; Roes, 1997; Van den Akker, 1988; Van den Berg, 1996). Certainly, synthesizing sources such as these should form a starting point for this portion of the program. But since this program aims specifically to assist in the creation of exemplary lesson plans for secondary level science and mathematics education in southern Africa, the support offered within the program should (as much as possible) be based on insights gained from experience in this area. An effort should be made to distill and apply the lessons learned from secondary level science education materials development endeavors such as those in Botswana (Kikstra, 1998; Thijs, 1999), Lesotho (Morobe & Polaki, 1996), Namibia (McKenney, 1995; Ottevanger, Michaud & McKenney, 1996; Ottevanger 2001; Jennes & Peek, 1996), South Africa (Gray, 1999; Davies, 1995), Swaziland (Dlamini, Putsoa Campbell, & Lubben, 1996; Stronkhorst, Dlamini & Coenders, 1996; Stronkhorst, 2001) and Tanzania (Clegg & Osaki, 1998). Such lessons learned from both international literature and that which is specific to science and mathematics education in the given context include the guidelines summarized in Table 4.2 (next page).

Guideline	Implications
The users of the material should be able to, at-a-glance, ascertain what the proposed lesson is about in order to decide whether or not it is appropriate for their own use.	CASCADE-SEA should help the user to create a lesson summary that is both terse and easy to find. Connections to familiar resources, such as textbooks, should be included in such a summary.
A pre-requisite to a smoothly run lesson (especially in the case of new or innovative practices) is having the necessary materials and equipment on hand at the start of class.	CASCADE-SEA should (together with the user), generate a list of ways to prepare for the lesson (e.g. pre-mixing of solutions, background information, etc.). As much as possible, CASCADE-SEA should help the user to create any such supplementary materials (handouts, worksheets, etc.) by offering tools and resources to do so.
When faced with pressure to squeeze large amounts of content into already packed syllabi, teachers can use recommendations regarding how much time to spend on what kinds of activities.	In addition to realistically planning the time allotments throughout a lesson series, CASCADE-SEA should encourage materials developers to consider timing for each part of the lesson as well as suggestions on ways to efficiently and effectively conclude a lesson.
Both the system itself and the materials generated with the aid of CASCADE-SEA should contain reservoirs of what Ben-Peretz (1975) terms, 'curriculum potential.'	CASCADE-SEA should offer materials developers a wide variety of activity ideas (e.g. demonstrations, homework assignments, experiments, group projects, field trips, forms of assessment, etc.) which may be incorporated into the materials and serve as sources of inspiration for the end users.
Creators of curriculum (be it materials developers or classroom teachers) are more likely to incorporate outside ideas when they can easily be adapted for one's own context or situation.	CASCADE-SEA should offer materials components in dynamic, rather than static formats. The program should also encourage its users to do the same. For example, text descriptions of activities should be editable so that the materials developers may tailor them if desired. Also, alternatives, substitutions and improvisations for materials (such as laboratory equipment and supplies) which might be difficult to obtain should also be recommended in the teacher guides.
Where applicable, content-specific theories of learning in science and mathematics (as opposed to general theories that are applicable across domains) should be incorporated into the materials.	CASCADE-SEA should assist the user in articulating specific expectations (problematic areas related to that topic, typical misconceptions regarding the content, likely student questions/reactions) so as to better prepare the end user of the materials and thereby lower any potential threat associated with trying out new or innovative activities.
The design of a message can influence the way it is interpreted and used.	CASCADE-SEA should encourage materials designers to consider the visual form and style of the teacher guides they create. Further, they should strive for a layout that accommodates the way teachers generally use such lesson materials (laid open on the teacher's desk for reference during a lesson).
The materials creation process is often best served by multiple perspectives toward development.	CASCADE-SEA should provide support and resources for further elaboration and improvement of the materials generated, including development activities that may be carried out without the computer.

Table 4.1: Content guidelines for the development of materials in the CASCADE-SEA tool

Implementation

Fullan and Pomfret's (1977) review of research on implementation has been said to play a significant role in increasing the momentum toward considering implementation to be an integral component of curriculum development (Marsh & Willis, 1995). Implementation has been more traditionally viewed as one phase in a series of linear instructional design steps, as the ADDIE models (Wedman & Tessmer, 1993) would imply with their Analysis, Design, Development, Implementation, Evaluation sequence. Yet, an increasing appreciation has grown for the integration of the implementation perspective throughout the entire process (Doyle & Ponder, 1978; Fullan, 1991; Plomp, 1982; Van den Akker, 1988; Van den Akker, 1994).

In terms of creating exemplary curriculum materials for use within the target context, research has illustrated that the potential benefits of such resources may only begin to be realized when careful steps are taken toward implementation (Snyder, et al, 1992; De Feiter, Vonk & Van den Akker, 1995; Ottevanger & Van den Akker, 1996). Although a mere computer program is not likely to be able to play an active role in the field, CASCADE-SEA can (and should) assist its users in planning for implementation. Thus, this system should provoke its users to design from an implementation perspective. Such stimulation includes early consideration of potential methods to introduce materials to the end user group (*what* kind of implementation activities would be appropriate) as well as the presentation of tools to carry out those activities in practice (assistance on *how* to do it).

Evaluation

The terms, "summative evaluation" and "formative evaluation" were introduced in the 1960s, yet remain two of the most frequently used distinctions in evaluation typology (Scriven, 1994). Whereas summative evaluation is generally conducted after completion of a particular endeavor with the main aim of informing an external audience or decision-maker, formative evaluations tend to be carried out during development (often repeatedly) for the design/development team to be able to make improvements. Given the goals of the CASCADE-SEA program, it logically follows that support in the arena of evaluation will be most valuable to the materials developers if it addresses formative evaluation activities.

As previously mentioned (with regard to analysis activities), the original CASCADE program (and related research) should serve as a springboard for designing related aspects in the CASCADE-SEA program. In terms of program content supporting formative evaluation, it makes sense to examine both the research findings and the suggestions for improvement in this area. Nieveen (1997) asserts that CASCADE offers several benefits to its users (improves consistency in formative evaluation plans and activities; motivates developers; saves time; and helps provide justifications for decisions). It may be argued that these benefits are related to those aspects of formative evaluation that are emphasized in the program. She lists the salient attributes of the CASCADE program, in terms if its content, as being related to three main items: (1) treating evaluation as a systematically performed activity which is integrated in the development process; (2) supporting the user in determining the quality of lesson materials and generating ideas for improvement by judging the intended curriculum on its validity, practicality and effectiveness; and (3) including four main stages (preparation, data gathering, data processing and reporting), the content of which depends on contextual factors (such as: the stage of development of the lesson materials; the quality aspects on which the developer will focus during the formative evaluation; the facilities of the project and the role of the developer). To achieve the goals of the program and build on past work, it then follows that the evaluation component of CASCADE-SEA should also integrate these aspects.

Finally, it should be noted that the target user group for the initial CASCADE program differs from that of the CASCADE-SEA system. As discussed in Chapter 2, adapting innovations for transplantation into other settings is a task that should not be entered into lightly. CASCADE-SEA should evidence consideration of the fact that southern African facilitator teachers who develop lesson materials in cooperation with their colleagues at TRCs are likely to go about that process differently from Dutch professional curriculum designers who work more independently. In particular, it should be attuned to at least three influential differences: (1) the existing knowledge of teacher-developers who are likely to have had little formal education in the field of formative evaluation; (2) the dual purpose of this system in terms of supporting both curriculum development and, through that, the professional development of its users; and (3) the challenges faced by materials developers who must carry out their task in a second language (English).

Revision

Just as revision decisions for lesson materials should be rooted in the results of formative evaluation activities, development guidelines for the evaluation component of CASCADE-SEA should also be based on suggestions for improvement, generated by the original study. Most of the concrete recommendations in this area pertain to the support and interface aspects, which will be discussed in the following sections. However, Nieveen (1997) does recommend broadening the scope of the program content in terms of curriculum development stages. Since the CASCADE-SEA program supports additional aspects of the curriculum development process (and not just evaluation), integrating such dimensions would seem to be a logical way to proceed. For example, as previously discussed, the CASCADE-SEA system should help users to articulate what they are trying to accomplish with their materials. To help the user determine if those goals have been met, CASCADE-SEA should then integrate this information with the establishment of criteria used throughout the evaluation phase. This, in turn, should lead to recommendations on ways to generate revision decisions that are based on comparison/contrast of evaluation findings and the original intentions as stated by the developer(s). Lastly, users should be encouraged to consider not only the revision of their lesson materials, but also their basic beliefs. Especially in situations where an understanding of the context is deficient, developers should be stimulated to hone their own perceptions based on formative evaluation results.

4.2.2 Support

Comparatively speaking, the domain of EPSS as a field of study is quite young, having been born in the late 1980s and taken a foothold in the early 1990s. Earlier work in this area demonstrated a clear orientation toward 'proof of concept' thinking, as evidenced in the literature that populated journals at that time (for an overview of EPSS-related literature from 1989 to 1995, please refer to Hudzina, Rowley & Wagner, 1996). Here, emphasis was given to defining the field (cf. Gery, 1989; 1991) and discussing ways of exploring it (Pirolli & Russel, 1990; Stevens & Stevens, 1995). As the field has grown, an increasingly analytic and research-oriented perspective has begun to take shape. And, out of experience, contemporary thinking on the topic has shifted. Whereas earlier efforts seemed more enamoured with the idea of exploring what electronic *systems* could offer, a trend rapidly emerged in which *user performance* became central, with the supporting systems on the periphery (Winslow & Bramer, 1994; Rosenberg, 1995); hence the field of Performance-Centered Design (PCD) was born.

This is not to say that researchers, thinkers and developers stopped considering performance support system characteristics. Rather, it was argued that these people needed to overcome a data-centric history, originating (according to Gery, 1995) from computer-mediated transaction systems, in order to create different types of tools to meet the changing needs of users. This gave rise to articulation of fundamental forms of support (Gery, 1995), attributes and behaviors of performance-centered systems (Gery, 1997) and even methodologies for conducting PCD (Raybould, 2000). Synthesizing these and additional trends in the related fields of Knowledge Management Systems (KMS) and professional networks (especially communities of educational practice), has contributed to establishing development guidelines for the support to be offered in the CASCADE-SEA program. (For information relating to the link between PCD and KMS, please refer to Laffey, 1995; for information on professional networks of teachers, please refer to Lieberman & Grolnick, 1996; Moonen 2001; Putnam & Borko, 2000.)

"...In performance-centered design …the whole is greater than the sum of its parts. Much like attempts to understand the functionality and behavior of the human body, we can separate out the component systems and elements, but true understanding requires an integrated view since none of these systems or elements operates in isolation," (Gery, 1995, p. 54). As described in Chapter 2, the notion of electronic performance support is, in this study, characterized by four main elements: advice, tools, learning opportunities and communication aids. Yet, as the very nature of PCD implies a series of integrated interventions in a performance support continuum, distinctions between these elements become (and should remain) blurred - especially from the user's perspective. However, toward studying the discipline in general, and certainly toward developing the CASCADE-SEA program itself, efforts should be made to articulate the forms of support offered within systems based on PCD. So, development guidelines for this program should be based on insights relating to the four constituent parts. Table 4.2 below illustrates these guidelines for support within the CASCADE-SEA tool, based on the aforementioned trends in PCD (see especially Gery, 1991; Raybould, 2000).

Descriptor Continuum		Functions	Guidelines CASCADE-SEA should aim to provide:
Advice	*Tailor-made*	Provides warning of consequences Helps identify/set goals and priorities Feedback may be proactive/reactive	Reminders (Consistency) checks Heuristics
	Generic tips	Best practices Predictions Decision making support	Literature lists Examples/cases Heuristics Sample choices
Tools	*Internal*	Prepares (sub)tasks for execution Automates (sub)task execution Summarizes user actions	Templates Checklists (Flow) charts/Option trees Auto-complete/check/correct Auto-save/archive/copy Generates (draft) products Note-taking/personal reminders Histories (navigation, use, time, etc.)
	External	Extends (sub)tasks Links to related (sub)tasks	Programs Information Data
Learning opportunities	*Implicit*	Advanced organization Matches the desired flow of work	Visual appearance suggests a method for doing (sub)tasks Previews Sequencing Metaphors Monitoring
	Explicit	Answers (procedural or conceptual) questions: who, what, when, where, how, why	Demonstration Evaluation Explanations Instructions Illustrations Samples/cases
Communication aids	*Written (real-time or asynchron-ous)*	Facilitates internal communication (with individual colleagues or [parts of] the organization) Links to outside expertise	Shared knowledge/database Websites Bulletin boards List Servs Chat rooms
	Verbal	Fosters reflection Stimulates discussion/debate Provides or provokes coaching	Checklists Examples Instructions

Table 4.2: Support guidelines for the CASCADE-SEA tool

It should be noted that defining these distinctions serves the purpose of discussing and understanding (sub)system characteristics. The ultimate aim remains the creation of an integrated whole, in which these features are blended together. So, in addition to discussing individual component guidelines, attention should also given to system elements that come into existence as a result of component integration. With the overall aim of reducing the workload on the users and thereby allowing them to focus on the task at hand, the system -as a whole- should (as much as possible):

- Match the natural task flow by:
  - being layered for multiple levels of use;
  - presenting (only) relevant information at the time/point of need;
  - offering growth potential while minimizing need for interpretation of special terms.
- Allow the user to rely upon recognition instead of recall by:
  - providing (system-wide) search capabilities;
  - listing and linking histories of user progress, navigation etc.
- Feel friendly by being:
  - easy to learn (in coached settings);
  - inviting (once introduced to it, new computer users should feel motivated to use the system);
  - forgiving (allowing mistakes and opportunity for correction);
  - safe (users must not fear that experimentation can ruin something on the computer).

These guidelines should ground design decisions regarding the support offered in the CASCADE-SEA program. They also create some implications for the way the user goes about working with the system. In particular, they affect the design of the user interface. Interface guidelines are addressed in the following section.

4.2.3 Interface

The interface challenge during the creation of the CASCADE-SEA system is to design a program that helps the users create exemplary lesson materials by offering support through efficient and effective human-computer interaction. A wide range of options may be utilized in shaping such interaction, including: buttons (push, radio, checkbox); hot spots; limits (time, tries); manipulatives (point-n-click, drag-n-drop, sliders); menus (pull-down, list box); text (static, dynamic, hyper); user events; and windows (message, multiple, pop-up). Yet even more options exist in terms of designing the interface through which these interactions may take place.

Extensive research and literature offer suggestions on what constitutes good quality interface design (MIT Media Laboratory, 2001; Mok, 1996; Thompson, Simonson & Hargrave, 1996), as well as how to systematically go about the process of creating a good interface (Arlov, 1997; Microsoft, 1999; Neilson, 1994; Stevens & Stevens, 1995). In addition, the guidelines followed for the creation of the original CASCADE program interface, as well as the resulting interface itself are two resources that should especially be considered when planning the interface of the CASCADE-SEA program. For a detailed description of these guidelines, please refer to Nieveen, 1997. Because of its comprehensiveness and its natural link with the foundational tenets behind the development of this program, the seven development guidelines for the CASCADE-SEA interface (shown in Table 4.3) have been articulated. These are grounded in those of Microsoft (1999), and elaborated based on the others previously mentioned. (Please refer to Appendix E for a reproduction of Microsoft's *User-Centered Design Principles*.)

Functions	Guidelines
User in control	▪ Tasks may be automated, but the user (not the software) initiates actions. ▪ Users must be able to personalize aspects of the interface and should be as interactive and as responsive as possible. ▪ Provide exits and shortcuts
Directness	▪ Interface should be task-oriented (toward achieving desired goals) ▪ Users should be able to directly manipulate (representations of) information. ▪ Visual information and choices reduce mental workload, and metaphors are often intuitive ways of doing this. ▪ Navigation and actions (e.g. selection options) should be clear
Consistency	▪ Provide stability by making the user interface as familiar and predictable as possible. ▪ Consider consistency within an application, an operating environment, and within a metaphor. ▪ The system should be reliable in advice and performance ▪ Screen zones should remain constant (information areas, interaction areas, tool areas, etc.)
Forgiveness	▪ Minimize errors (and the need to correct them) ▪ Allow for interactive discovery (trial and error) by providing warnings where potential mistakes may occur. ▪ Accommodate for both physical and mental mistakes by making recoveries easy.
Feedback	▪ Provide appropriate, immediate feedback for user actions. ▪ Avoid unresponsive ('dead') screens.
Aesthetics	▪ Communicate important cues about system behavior while remembering that screen elements compete with each other for the user's attention. ▪ Use concise text and images, only functional elements (to inform, not impress)
Simplicity	▪ Strive for a balance between simplicity (easy to learn, easy to use) and functionality. ▪ Reduce clutter by building on the user's existing knowledge and by progressive disclosure (show only relevant information for certain tasks, not all information for all tasks).

Table 4.3: Interface guidelines for the CASCADE-SEA tool

Along with the rapidly-growing body of knowledge related to (graphic) user interface design and usability engineering, relevant instructional design sources should also be consulted, to study (any) implications of content-related interface issues. For example, Jonassen & Tessmer, (1997, p. 23) "…emphasize that [designing new instruction] is not a linear decision-making process as much as a concurrent one." If the visual appearance of the system should (as noted in the previous section) reflect the method(s) through which curriculum materials are to be made, and that process is more concurrent than linear, then the interface ought to allow users to access various parts of the program at will (and not only in a linear fashion). Another example stems from Moore, Burton & Myers' (1996) research on multiple-channel communication which suggests that multiple-channel presentations can be superior to single channel presentations. Such findings present a good argument for building redundancies into the program interface (e.g. more than one way to access Help files).

Finally, the process through which a program is developed can impact the decisions made about an interface. Developers should exercise caution while building early prototypes, as premature interface decisions make prove difficult to un-make, later on. The result can be that remaining development resources are insufficient to effect (often deep-seated) interface changes; and prototype functionality fails to be optimized due to this separate, but related, issue. Whereas some authors prefer extensive use of paper-based prototypes as a solution to this issue (Landay, 1996), others call for increased front-end analysis. "By making the right choices you can avoid wasting development effort and deliver a system that will increase users' productivity," (Raybould, 1990, p. 14). Among his list of key decisions in this area, Raybould (1990) highlights that of development platform selection.

Since desktop computers became a staple in the modern work environment, the software industry has seen an explosion of activity. Not only has this lead to increased production and distribution of software, but the types of applications on the market have evolved at a dizzying pace. One type of application that has seen significant growth in the last 15 years is development platform technology: programs that help users to build (other) programs. Useful reviews have been written for generic tools (Seachrist, 1996; Stevens & Stevens, 1995) and articles may also be found regarding tools that specifically help build instructional environments (Merrill & Thompson, 1999; Murray, 1998; Spector, 1999; Wright, Harper & Hedberg, 1999). Platform technology decisions based on the aforementioned literature should be tempered with the following considerations:

- A needs/context analysis prior to the start of design activities revealed much information regarding the use of computers in the target context. This included information on the platforms used (Windows™, Mac™, Internet-based) in potential trial settings. Although Windows showed to be the dominant operating system in most countries, some (Botswana, parts of Namibia) use(d) mostly Mac systems. In order to keep research options open, an effort should thus be made (as long as it is feasible) to develop CASCADE-SEA prototypes that may run in varied environments.
- The researcher in this study has had no training in developing software. But, in light of the research goals, the decision was made to educate the researcher/developer in this area so that truly rapid prototyping would be able to take place. This implies that the authoring environment

should be appropriate for non-professionals (following an initial investment in training) with as much 'room to grow' possible, in terms of functionality.

- Based on the anticipation that the CASCADE-SEA program is likely to evolve through numerous prototypes, the authoring environment should (as much as possible) facilitate the easy transition of some or all pieces of programming from one version into the next, with a minimum of re-programming.

4.3 Product specifications

The platform of ideas that contributed to the design of the CASCADE-SEA program contains three rather distinct layers, as mentioned at the beginning of this chapter. Together with the foundational tenets, the guidelines discussed in the previous section caused developers to consider various alternatives in structuring the CASCADE-SEA program. This section describes the most concrete layer of the platform, which builds on the previous two: product specifications. Whereas the tenets and guidelines illustrate (different levels of) developer intentions in terms of *what* the program should be like, the specifications represent developer ideas on *how* to implement those ideas inside the program itself. As with the tenets and guidelines, these too evolved along with researcher/developer insights. In fact, most of the specifications presented in this section emerged throughout the study, based on insights from formative evaluation activities as well as the ongoing literature review.

Due to the sheer volume of product specifications generated for the CASCADE-SEA program throughout its four-years of design and development, a comprehensive recount seems inappropriate for this book. Instead, this section aims to portray the nature of product specifications (what do they look like?) as well as their evolution (how were they derived?) through selected examples. Since most specification documents range from one to seven pages in length, those presented here are excerpts from larger documents, which are located on the CD-ROM at the back of this book, see Appendix F. Additional specifications may be inferred by studying the program itself, in Appendix G. Because the final version of the CASCADE-SEA program contained four main components, one example will be presented from each area: rationale, analysis, design and evaluation.

Note: the reader is advised that these samples have been extracted from original, internal documents. With the exception of minor re-formatting (to the layout of this book), no adjustments have been made for to the content or structure.

4.3.1 Rationale component specifications

In addition to specifications regarding detailed elements of the rationale component, three specification documents for the overall structure of this portion of the program were generated: Rationale Ideas; Rationale Template I; and Rationale Template II, located in Appendices F-1, F-2 and F-3, respectively. Toward understanding the example, the text below briefly explains what this part of the program is about and how these specifications were created. Box 4.1 below is excerpted from Rationale Template I.

What is the rationale component like?
The rationale component of the CASCADE-SEA system is designed to help users walk through a brief reflection on what they wish to achieve with the (to be created) materials. Not only is this type of reflection considered to be a critical step in creating good quality lesson materials, it also serves an important function with regard to the support offered by the computer throughout the rest of the CASCADE-SEA program. Namely, the information entered by users as a result of their reflection is then used by CASCADE-SEA to determine which recommendations, tools and templates should be offered.

How was this specification document (Rationale Template I) created?
Next to the aforementioned tenets and guidelines, additional literature was consulted (refer to Appendix F-1 for details). Further, a developer screening helped fine tune initial versions of this document (see Appendix F-3) and later, of this part of the program itself.

… (continued) …

What the user is asked to think about	Application of this information
Why: Aims (What kind of support do you wish to offer your users?) *Teaching Methods* This material will help teachers improve their teaching by ____(briefly explain what kind of teaching you want to have take place)____. *Subject Matter* This material will help teachers better understand the topic of __(type your topic here) because __(explain why it's difficult)__. *Basic teaching skills* This material will help teachers improve their basic teaching skills such as timing, safety and classroom management, as well as___(add your own items here)___.	Text entry (finish the sentence) allows the user to briefly explain what kind of support in selected areas would be desirable. If teaching methods is checked, Cascade will remind the user to take a look at the idea book (both parts: one with suggestions for ways to improvise when resources are scarce, and one with classroom activities). If subject matter support is checked, then Cascade will remind the user to include a glossary and extra explanation for the teacher during the design of materials (which are otherwise optional). If basic teaching skills is checked, then Cascade will provide reminders when the user is working on timing, as well as safety and classroom management reminders when activities are selected. Also, an option will be offered for users to fill in their own ("other") aims. But Cascade will only be able to offer support on known options.
Who: Target Group (What do you know about the users of your materials?) Are the teachers in your region similarly qualified? If yes, then please rank them as: Well qualified but still inexperienced Poorly qualified and inexperienced Well qualified and experienced Poorly qualified but well experienced (is this one realistic?) If no, then please click all that apply: (Same list, but more than one option is enabled)	The yes answers will be elaborated through radio buttons (check one choice) while the no answers will be elaborated through multiple choice buttons (more than one box may be checked at a time). The main reason for asking this question is to inspire the user to reflect on his/her colleagues in ways they might not otherwise consider, if not explicitly asked. Cascade users will also be offered this advice (depending on selections): (1) Well-qualified but inexperienced teachers will need more support that helps raise their confidence, and less support in the subject matter. You can do this by offering procedural specifications for classroom activities. (2) Poorly qualified and inexperienced teachers will need a balance of subject and pedagogical support. This might be…

… (continued) …

Box 4.1: Excerpts from rationale component specifications (Rationale Template I)

4.3.2 Analysis component specifications

In addition to highly detailed elements of the analysis component, specifications regarding the overall structure and approach used were laid out in five specification sets: Analysis Product specifications I, II, III, IV, and the Analysis Questions Overview located in Appendices F-4, F-5, F-6, F-7 and F-8, respectively. Toward understanding the example, the text below briefly explains what this part of the program is about and how these specifications were created. Box 4.2 below is excerpted from Analysis Product specifications III.

What is the analysis component like?
The analysis component helps the user who has indicated uncertainties regarding design preferences (usually carried over from the rationale section). In particular, the analysis phase will help the user research unanswered (rationale) questions through three strategies, but originally (at the time this document was created), four strategies were being considered. The selections of the table below illustrate specifications for support to be offered once strategies and related methods have been selected.

How was this specification document (Analysis Product specifications III) created?
In addition to the aforementioned tenets and guidelines, additional literature was consulted. The guidelines used to create the evaluation component (this was done earlier) were especially useful. Further, a developer screening helped fine-tune initial versions of this document and later, of this part of the program itself.

... (continued)...

		Types of support	Comments
Instruments	Sample instruments will be offered for the various methods suggested	Document analysis: three versions of checklists will be offered, one for use within a curriculum profile, one for use within a materials inventory and one for use within an issues synthesis Classroom observation: only one version of an observation scheme will be offered for use within a curriculum profile Interview: four versions of interview schemes will be offered, one for each approach Questionnaire: four versions of questionnaires will be offered, one for each approach ...	The instrument versions will vary based on the kinds of information they aim to obtain. For example, document analysis checklists for use within the curriculum profile approach will focus on gaining a better understanding of the formal and operational curricula. This implies a study of the syllabus (and like documents) and the documents teachers use in their classrooms (handouts). In contrast, a checklist for use within a materials inventory will focus on classification of already available materials. Finally, an issues synthesis will be aimed at studying policy documents ...
	... (continued) ...		
Respondents	Tips on contacting and working with respondents will be offered in this section. Whereas evaluation addresses three types of respondents (teachers, learners and experts), this section might have a different typology: teachers, learners, headmasters, curriculum developers and policy-makers		Are there other kinds of respondents that should be taken into consideration? Parents could be interesting when it comes to either an opinion poll or an issues synthesis, but I'm not sure that it would be appropriate at this stage.
Design Guidelines	Cascade will help the user make sense of the information by offering some support for generating product specifications based on the information obtained. Heuristics will be given for: discussions within a design team and creating an overview of the aims. A "revise rationale" page will also be offered that the user can fill in here (changes in rationale will automatically be updated) with regard to the unanswered questions indicated in the beginning of this section.		How else can support be offered here? In particular, how can I offer support here that is not redundant to the rationale support?

Box 4.2: Excerpts from analysis component specifications (Analysis Product specifications III)

4.3.4 Design component specifications

Although additional design component specifications emerged later, this area initially featured support for the creation of lesson plans (and was called, the Lesson Builder). Plans for this component were described in two specification sets: Lesson Builder Projected Features and Lesson Builder: Master Choice List (located in Appendices F-9 and F-10, respectively). Toward understanding the example, the text below briefly explains what this part of the program is about and how these specifications were created. Box 4.3 below is excerpted from (the Lesson Builder: Master Choice List).

What is the design component like?
CASCADE-SEA should generate draft lesson materials for the user. In order to provide as much guidance possible, the draft is based on a lesson template, with support for customizing the various elements. This list shows (early) ideas on how to structure the template and support.

How was this specification document (Lesson Builder: Master Choice List) created?
Along with the aforementioned tenets and guidelines, additional literature was consulted. Further, a developer screening and expert appraisal helped fine tune this list.

Preparation

Media and materials

The following items will be needed for this lesson's activities:

- ____________________
  (To create this list, users may choose from an existing list of commonly used items and/or add their own supply items. Perhaps an interesting feature would be an icon indicating a tip for obtaining certain items at low cost. For example: paper * *Clicking on the * yields this info:* Try contacting your local newspaper to see if you can get scrap paper cheap or free.)
- *Also available in this area of Cascade: a "toolbox" of links to programs which help with the creation of support materials such as power point, a paint program, etc. Suggest that teachers make vocabulary lists, handouts, posters, etc.*

To do before class

- _________________ *(Include information regarding any specialized preparation they might need to do, in addition to just gathering materials. This information will be obtained via text entry)*

What to expect

These tips will be obtained via text entry.

- Common misconceptions *(try to break this down further, like in homework)*
- Problematic areas for pupils
- Other

Execution of the Lesson

Introduction

- Check homework by
  - O *learners present work*
    - *O Individually*
    - *O In pairs*
    - *O In groups*
  - *O learners exchange work*
  - *O teacher collects work*
  - *O teacher simply looks to see if the assignment has been completed*
- Tell the learners that the topic of discussion will be __________ which is covered in Chapter ___*(#)* in the textbook. Write pages ______*(23-26)* on the board.
- Motivate learners by __________ *(choose an existing Lesson Starter from the database, or create your own)*
- Explain to learners that they will be doing _______ ____________ *(builder fills in the types you selected)* today, and that this is important because ____

… (continued) …

Box 4.3: Excerpts from design component specifications (Lesson Builder: Master Choice List)

4.3.4 Evaluation component specifications

In essence, the product specifications for the evaluation component were derived from those generated for the original CASCADE program. The differences in these areas are minor, reflecting changes in: (1) language (English translation and some simplification of texts); (2) fewer options from which to select (these were condensed); and (3) a different approach to handling contextual constraints and opportunities. Naturally, changes due to a different programming environment and a new interface were also implemented. Because detailed descriptions of the original specifications are available in Nieveen (1997), only one example is offered in this book. This (modified) Formative Evaluation Approaches Matrix is based on that of Nieveen (1997). Toward understanding the example, Box 4.4 briefly explains what this part of the program is about and how these specifications were created.

What is the Formative Evaluation Approaches Matrix ?
CASCADE-SEA supports the user in conducting a formative evaluation of the lesson materials (being) developed. In so doing, the user is asked to indicate the state of development of the materials (global outline, written in partial detail, or completely created) as well as the quality aspects upon which they would like to base their evaluation (validity, practicality and effectiveness). The program then offers the users advice on which evaluation approaches are best suited to the user's situation; the options are developer screening, expert appraisal, micro-evaluation and/or tryout. This matrix shows how that advice is selected.

How was the Formative Evaluation Approaches Matrix created?
The original CASCADE program specifications were used as a springboard for this matrix (please refer to Nieveen, 1997 for a detailed description). Alterations were made based on insights regarding the (different) target user group and the anticipated desire for a condensed approach.

		Stage of development		
		Global	*Partial Detail*	*Complete*
Quality aspects to investigate	*Validity*	DS EA ✓	DS EA ✓	EA ME ✓
	Practicality	DS EA	EA ME ✓	ME TO ✓
	Effectiveness	DS EA	EA ME ✓	ME TO ✓

Legend:
DS = developer screening
EA = expert appraisal
ME = micro-evaluation
TO = tryout
✓ = recommended only if extra time and resources are available

Box 4.4: Excerpts from evaluation component specifications (Formative Evaluation Approaches Matrix) based on Nieveen (1997)

Developers relied more on product specifications such as these during initial stages of conceptualization and development. In later stages, screen shots and hands-on sessions served as discussion tools for honing the design principles. While (both internal and external) formative evaluation findings yielded recommendations for improvement, most prototype revisions were integrated directly into the program, without additional documentation of (revised) product specifications. However, a simple comparison of the specifications (see Appendices F-1 - F-10) and their target areas in the final version of the CASCADE-SEA program (located on the CD-ROM at the back of this book, see Appendix G) would yield this information, if desired. The next section elaborates on the evolution of product specifications as they took shape within individual prototypes.

4.4 Global prototype descriptions

"Prototypes," says Cisco Systems CIO Peter Solvik, "are far less ambiguous than words," (Schrage, 1999, p.1). While design tenets, guidelines and specifications proved extremely useful to the developer team for generating ideas and alternatives in early stages of design, working prototypes were used to gather such input from users and experts. This approach was selected for two main reasons, relating to the foundational tenets of authenticity and mutual benefit.

First, it was the opinion of the researcher/developer team that working prototypes would provide a distinct advantage over written descriptions in terms of efficient and clear communication. Rather than having to struggle to understand detailed specifications written in a second language, the users could respond to what they experienced. Further, this approach minimized the risk that users would infer certain features (from the specifications) that the developers did not necessarily mean to imply.

Another reason for choosing to gather external responses through working prototypes relates to the notion that developers needed to maintain a dual focus throughout this research. In particular, it was a priority to structure formative evaluation activities in such a way as to serve the professional development needs of the participants. By engaging (usually voluntary) users in small scale prototype evaluations, both researchers and participants benefited from the experience.

As noted in Chapter 3, the CASCADE-SEA program evolved through four prototypes to a final version. Each of these prototypes, following significant modifications, was later integrated (conceptually, and in some cases, also technically) into the final version. For this reason, the following text offers very brief descriptions of the prototypes. Section 4.3 describes the final version (including the pieces based on prototypes) in detail.

4.4.1 Prototype one

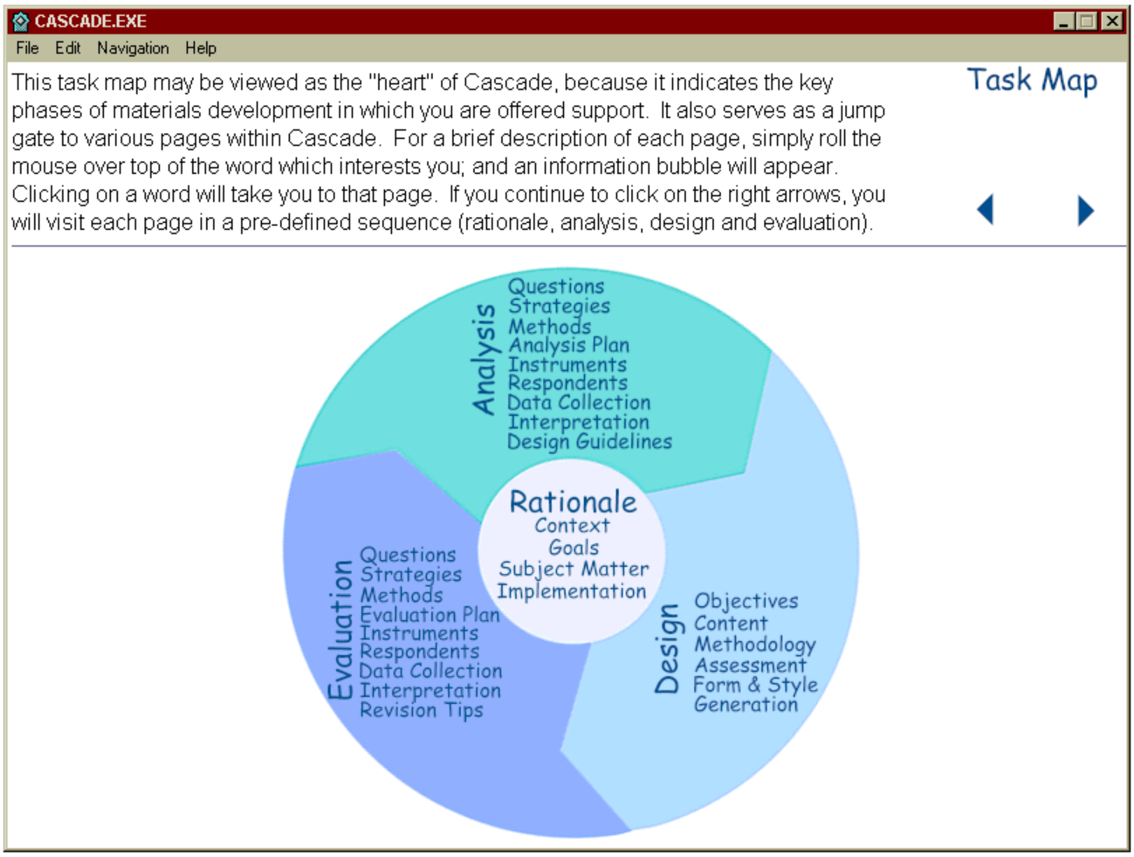


Figure 4.2: Prototype one (task map screen)

Figure 4.2 shows the task map screen from the first prototype. This prototype was an initial attempt to integrate the various components of support for materials development into one tool. The main goal was to gather ideas about the structure of this tool as a whole, before elaborating individual components. According to Walker (1990, p. 498), "curriculum materials design is... the building of intricate layers of order - program, course, unit, activity, content, purpose, structure, approach. The many hundreds of decisions embodied in each layer are subject to many disparate considerations. The materials that result are woven from these simpler decisions as a tapestry is woven from single-colored threads. In curriculum materials the quality of the final product depends on the total configuration decisions and on how well they are carried out in creating the actual materials." In accordance with such thinking, this research began by considering how to support curriculum renewal in terms of the 'total configuration.'

In this version, the basic elements of analysis, design and evaluation were integrated into one system, along with the rationale. Heavily based on the original CASCADE program, the evaluation component was far more elaborate than the rest of the system. Whereas most of the evaluation component was functional, the screens in the other three sections contained ideas and option lists of elements that might be (eventually) built in to them. The main aim of this prototype was to establish (and collect feedback on) a conceptual and procedural model for curriculum development. Formative evaluation activities with this prototype collected information on what participants would change and why; and later focused more on how intelligent support and improvements could be built in the areas defined. The developer screening instrument found in Appendix C (W-DEV1.8) provides additional information through 41 screen shots from this program.

4.4.2 Prototype two

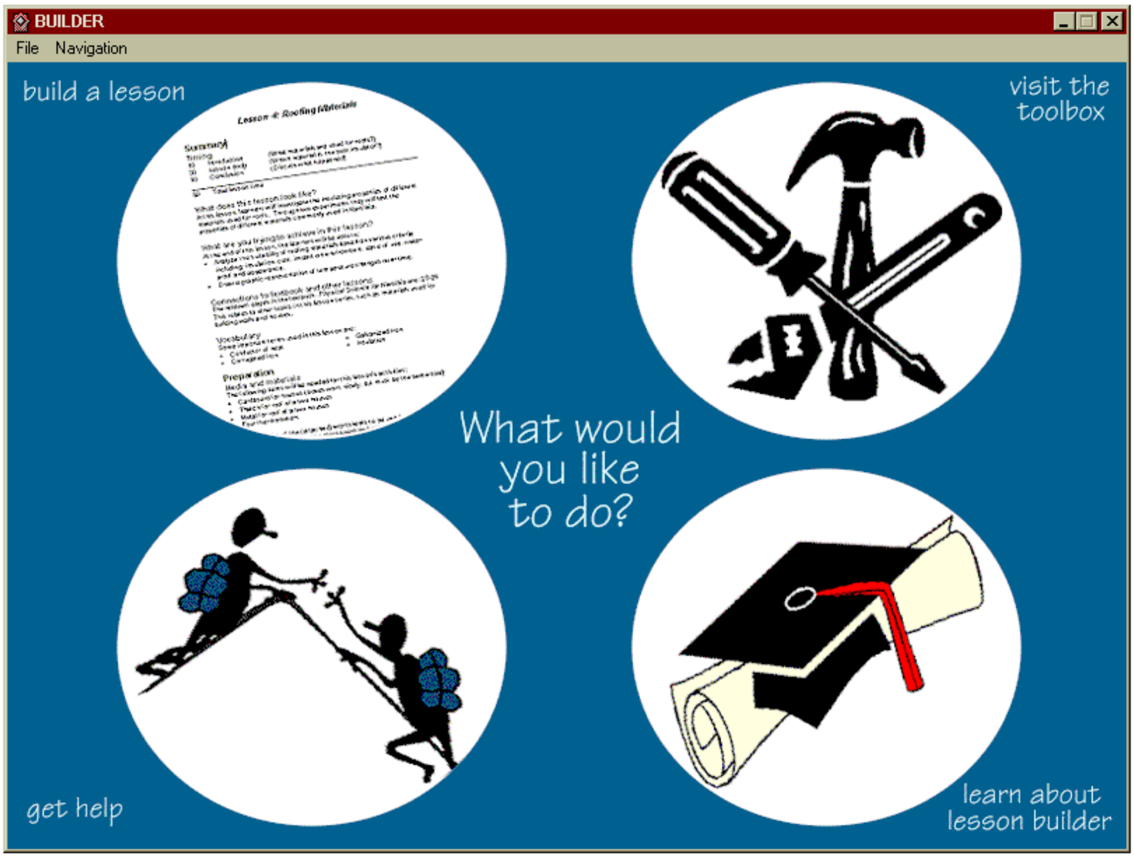


Figure 4.3: Prototype two (main menu screen)

The second prototype, pictured in Figure 4.3, supported only one sub-component of the curriculum development process: building individual lessons. For trialling purposes, this prototype was designed to run independently from the previous (integrated) program, but with the intention of being able to merge the two, later. As the main menu illustrates, there are four areas of activity (see circles): Build a lesson; Visit the toolbox; Learn about lesson builder; and Get help.

The Build a lesson area of the program was actually the heart of the program, and the central location for designing lesson materials. It helped users to generate lesson summary, things to do in order to prepare for the lesson, and (of course), the lesson itself. Further, this portion of the program connected the user to a (functional, but not elaborate) database of lesson activities. Here, users could search through existing entries (games, demonstrations, experiments, etc.) and add them to the lesson plan with the click of a button. In addition, users could add their own activities to the database, which would then expand with each user's contribution(s). The Toolbox area featured additional software (external) that could be used to elaborate the lesson materials generated by the lesson builder. Tutorials on how to navigate through the program, build lessons and customize them were located in the Learn about lesson builder area. Finally, the Get help area offered access to frequently asked questions, an index and a search function. Additional information is located in Appendix C (W-DEV2.12), through the screen shots provided in the developer screening instrument.

4.4.3 Prototype three

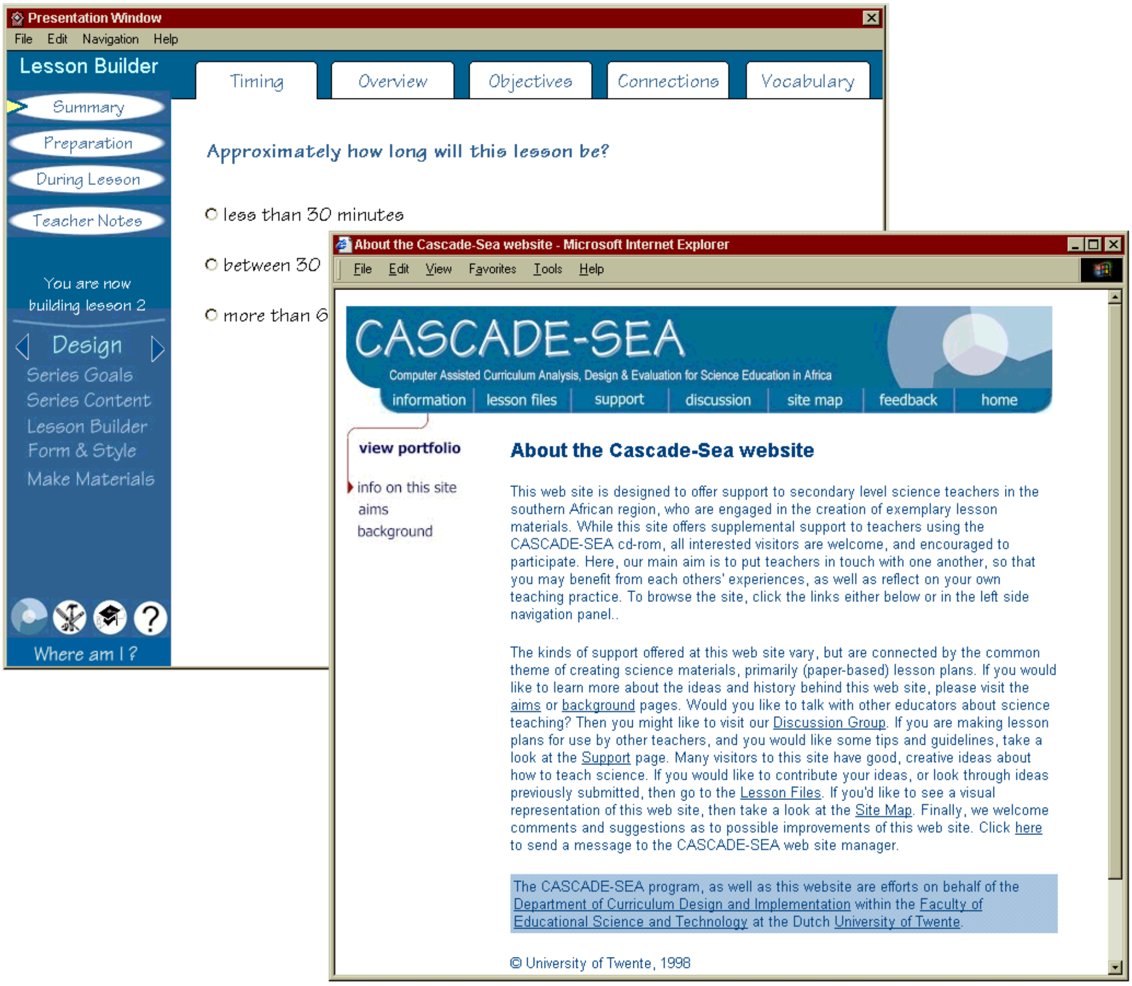


Figure 4.4: Prototype three (design screen and web interface)

The third prototype of the CASCADE-SEA program integrated the main elements of the first two prototypes along with many of the additions and revisions that were proposed as a result of evaluation circuits. Also, the rationale component was elaborated to assist users in articulating the ideas behind their materials development activities. Further, the CASCADE-SEA user support website was established at this time. Figure 4.4 shows both the website (top) and the second integrated prototype (in the design area). For additional information regarding prototype three, please refer to the developer screening instrument in Appendix C (W-DEV3.15).

4.4.4 Prototype Four

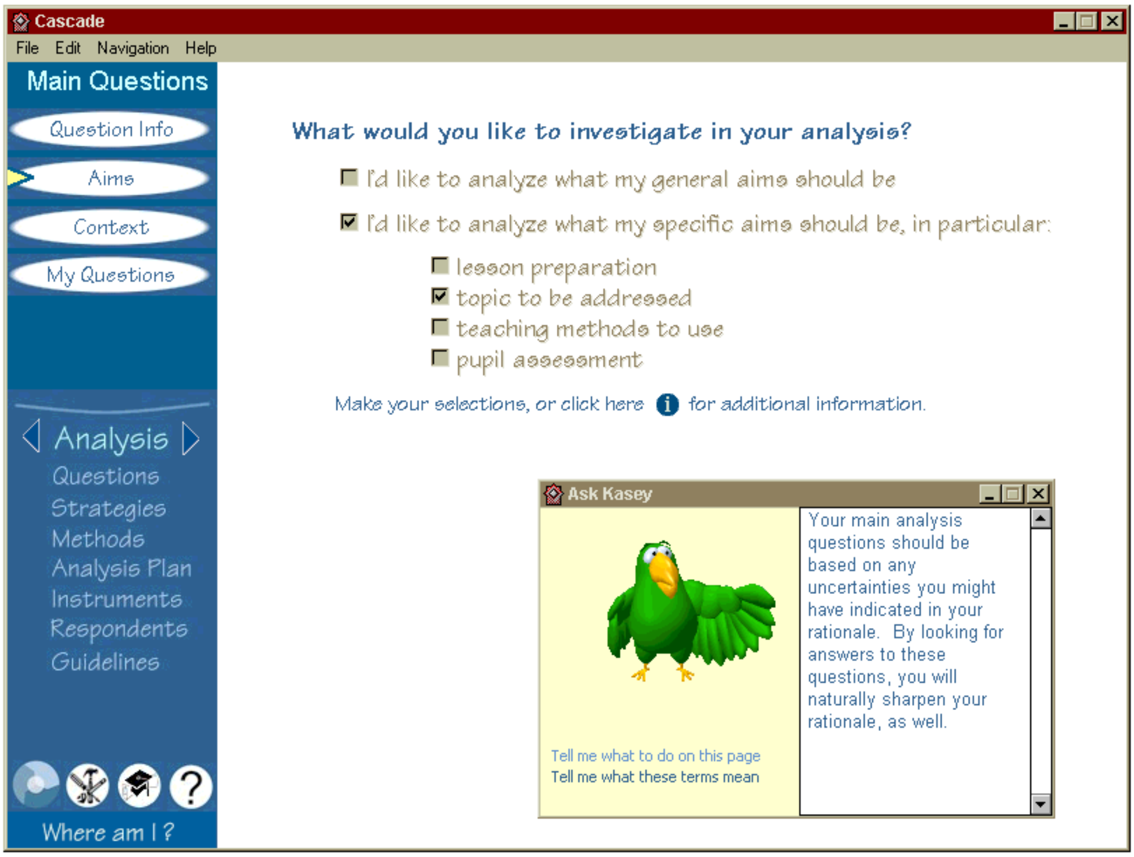


Figure 4.5: Prototype four (analysis screen with interactive agent)

The fourth prototype, as illustrated in Figure 4.5, added support for analyzing the user's context and needs. This component was inserted into prototype three, thus extending its functionality. Further, support was extended through the addition of Kasey, the voice of CASCADE-SEA. Please refer to Appendix C (W-DEV4.25) for additional information regarding this prototype.

The final version of the program polished up and elaborated the elements found in the fourth prototype. For example, Kasey's functionality was increased, the database of activities (in the design component) was significantly enlarged and the navigation bar was redesigned. Finally, professional versions of supplementary software were integrated into the package. Section 4.5 offers a detailed description of the final version of the CASCADE-SEA program.

4.5 Detailed description of the final version

As previously described, the CASCADE-SEA program evolved through four prototypes before arriving at a final product (although researchers are likely to continue this line of inquiry, thus the term 'final' is relative). This program consists of two main elements: a CD-ROM (or 16 diskettes) and a website. This section features a description of both of these elements.

As noted in section 4.2, it can be useful to distinguish between the program content, support and user interface. At the same time, describing these aspects in isolation is nearly (if not completely) impossible. For organizational purposes, this section begins with a description of what the program does (highlighting its content), and then summarizes forms of support and interface issues. But it should be emphasized that, to some extent, the distinctions drawn here are arbitrary.

4.5.1 Content: CD-ROM

The CASCADE-SEA CD-ROM aims to support those groups and individuals involved in the process of creating exemplary lesson materials or teacher guides, usually to be shared among colleagues in the same region. The main menu screen, presented in Figure 4.6, shows both the procedural and conceptual model for curriculum development that is supported within this program. Although the model itself (representation and nomenclature) is unique, the ideas behind this model are clearly based on a synthesis of the design models described in section 4.2.1.

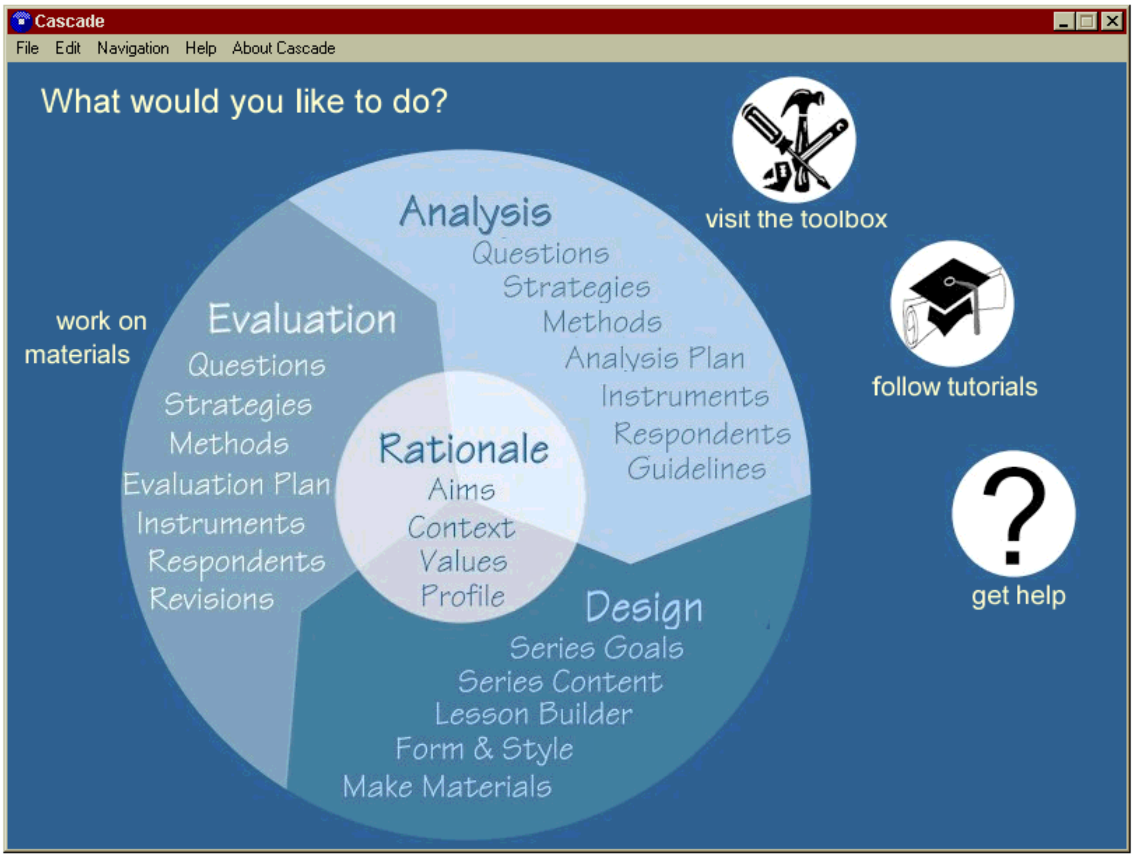


Figure 4.6: Final version (main menu screen)

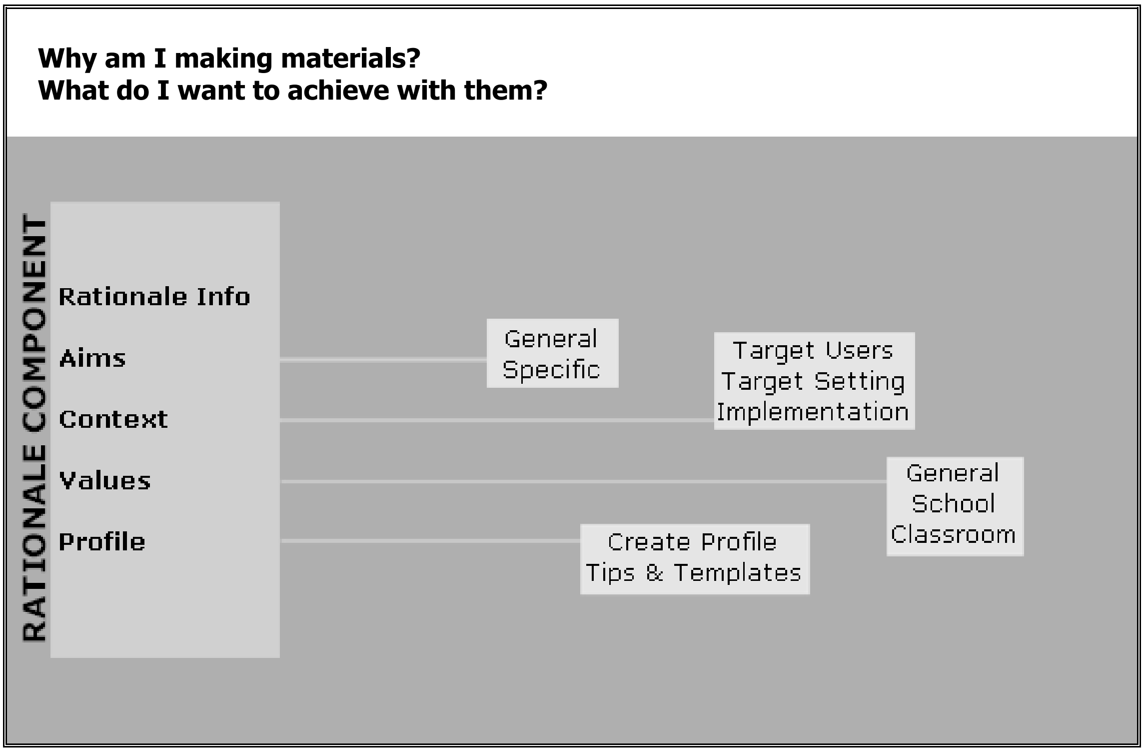
This model may be classified as cyclic (emphasizing an iterative approach) as well as organic (explicitly featuring the core ideas driving the innovation). As this model depicts, four main phases of curriculum development are discerned: rationale, analysis, design and evaluation. The rationale contains the main aims and ideas behind the (to be developed) curriculum, including their implications with regard to the target setting. Located at the hub of the process, the rationale phase influences all others. The process of defining a rationale is likely to raise additional questions. In many cases, the best way to answer (some of) these questions is to conduct a needs and/or context analysis. An elaborated rationale provides the curriculum developers with guidelines during the design phase and may also serve as criteria against which (formative) evaluation can take place.

In addition to the four main components, four additional features bear mention: help, tutorials, an interactive agent (named Kasey) and a toolbox containing additional resources. The following content description begins with the four main components and then moves on to the four additional features. Due to the detailed nature of the program, (including approximately 250 different activity screens), this description is limited to the most significant elements within the various components. Each component description contains a map (illustrating the component structure) as well as one screen shot from that portion of the program. For additional detail, please refer to Appendix G, the CASCADE-SEA program itself, located on the CD-ROM at the back of this book.

Main Components

Rationale

This portion of the program has been designed to assist the users in reflecting on their own ideas by focusing on the questions of who, what, where, when, how and why as they pertain to the (to be created) exemplary lesson materials. This portion of the program serves two purposes simultaneously. First, it stimulates the user to reflect on their own (often not-as-yet articulated) ideas with regard to the creation of good quality lesson materials. As discussed in Chapter 2, such reflection promotes professional development while simultaneously improving the quality of the curriculum being developed. Second, throughout this portion of the program, the computer is gathering information about the users. This information will later be used (in the analysis, design and evaluation components) to provide tailor-made advice, based on the user's own situation.



Box 4.5: Rationale component map

As illustrated in Box 4.5 this component contains four main sections: aims, context, values and profile, in addition to information about this portion of the program. The rationale information area of the program explains to users that this is the place to reflect on what they would like to achieve with their lesson materials. It also defines what a rationale is and describes how this component is structured.

The aims section contains two areas: general and specific. The general area asks the user to consider which portion(s) of the curriculum or syllabus will be the focus of the materials to be developed. The computer assumes that users are creating lesson materials to help teachers implement a challenging or new curriculum, and therefore suggests that these materials will aid in: lesson preparation and management; understanding of subject matter content; teaching methods and didactics; or assessment and monitoring. Once users have made selections in this portion of the program, they are encouraged to elaborate this information in the specific area (see Figure 4.7). Here, the user may provide additional detail in these four domains. For example, those who have chosen to address subject matter content in their lesson materials may indicate the subject (biology, chemistry, physics or mathematics) and the topic (eg: animal nutrition, enzymes, photosynthesis etc.) to be addressed in these materials. In most cases, this is done by selecting one or more items from a pre-formatted list; most pages also offer the opportunity for users to enter alternative items, as well.

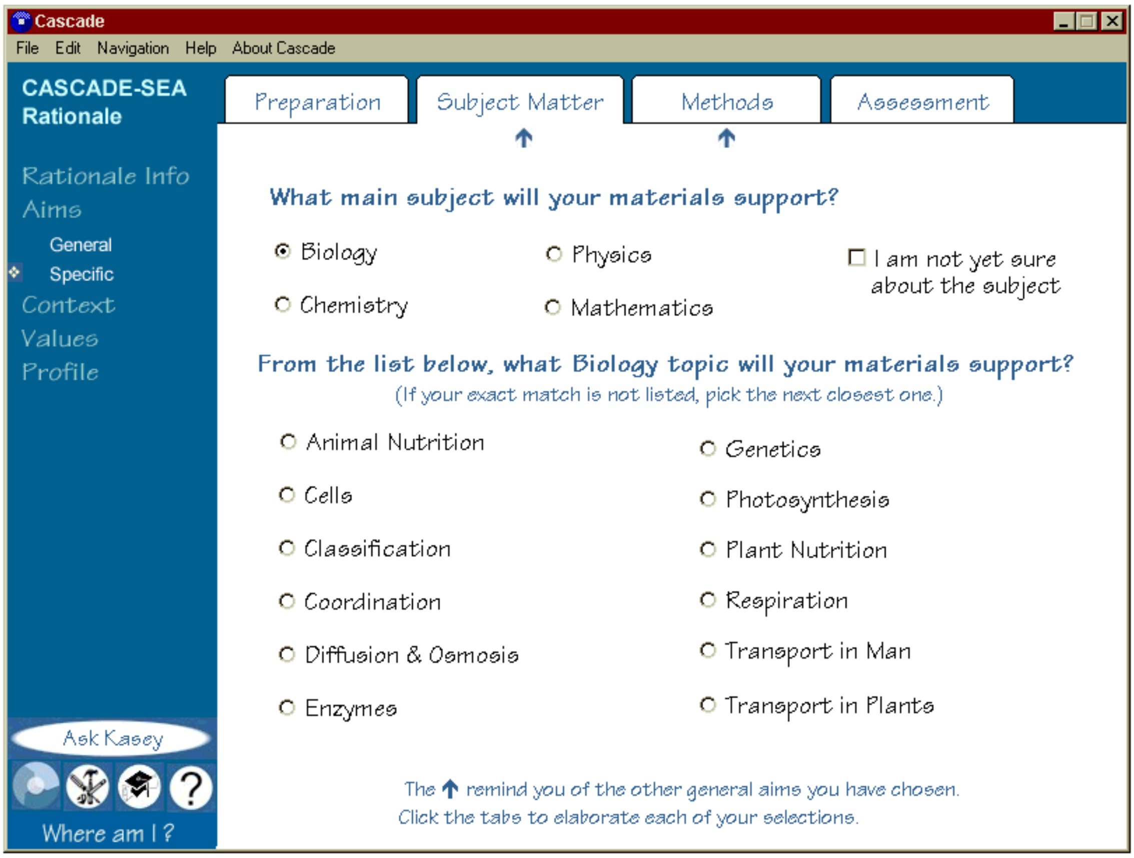


Figure 4.7: Final version (rationale screen)

The context section contains three areas: target users, target setting and implementation. The target users area suggests that the curriculum developer(s) consider those who will eventually use the exemplary lesson materials being generated through the system (and what implications such characteristics may have for the materials design). In particular, attention is given to qualifications (whether or not the eventual users of the materials have the appropriate diploma to teach); experience (in teaching) and motivation (to work with this particular curriculum). In the target setting area, CASCADE-SEA suggests that the curriculum developers(s) consider the schools in which their material will eventually be used (and any implications their facilities -or lack thereof- may have for the materials). The implementation area of the program stimulates the users to consider, from very early on, how the (to be produced) materials will be integrated into the daily practice of the target users. Throughout the aims and context sections, each page contains a check box through which the user may register that they are not sure about the decision(s) made on that page. Any indication of uncertainty is later carried over to the analysis component, in an effort to remind the user of important areas for further clarification.

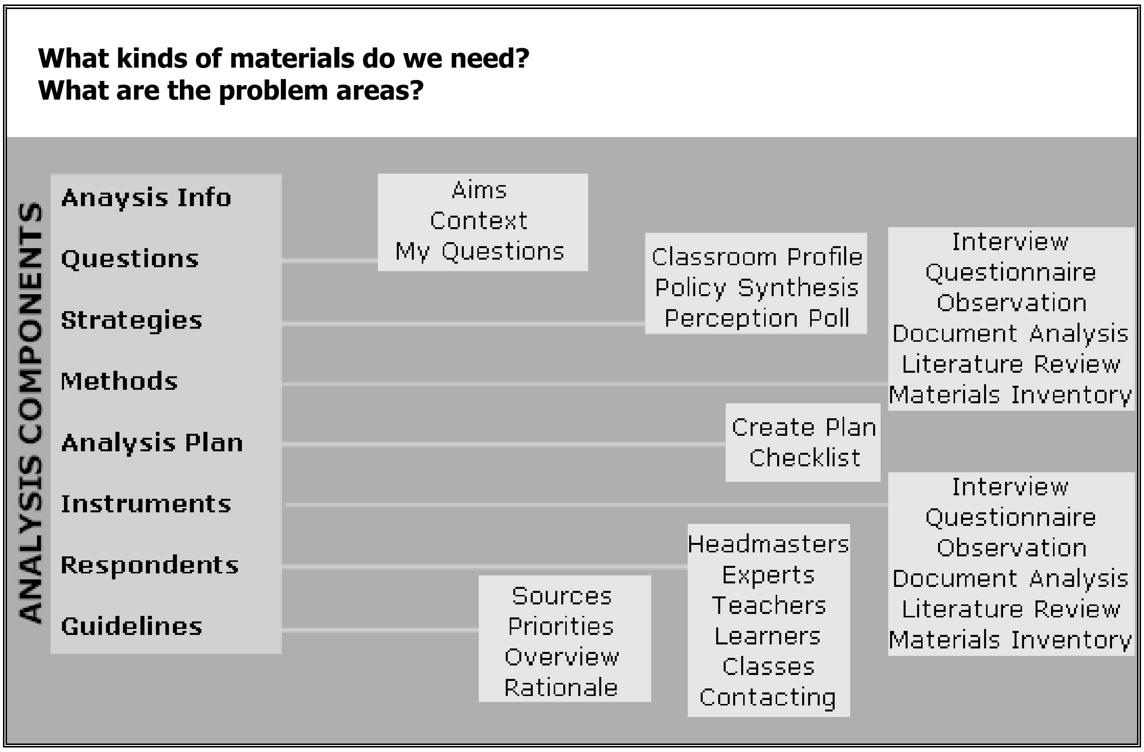
The values section of the rationale component is composed of three areas: general, school and classroom. In this portion of the program, users are encouraged to reflect on their own educational philosophy (or at least those ideas that should be purveyed through their materials). This section includes consideration of such issues as: the essence of education; the environment of education; the atmosphere of the school; the role of the teacher; and preferred teaching methods.

In addition to explanation, the profile area contains two main sections. First, CASCADE-SEA creates a rationale profile based on the aims, context and values indicated by the user. It points out that this document may be a useful discussion tool within a design team, to identify unanswered questions which must be addressed in an analysis, to begin to structure guidelines for the design of the materials, and to provide criteria for formative evaluation. When the user clicks on the Create profile button, CASCADE-SEA offers a suggestion as to what activities should be undertaken next, such as this one: "Your rationale indicates that you still have some important questions to answer with regard to your main aims. Cascade recommends that you do an analysis before you start designing your materials." Thereafter, the profile is presented on screen. It may be printed, or exported into a word processor for customization and editing. This latter function is strongly recommended by CASCADE-SEA, and suggestions are given on how to go about doing this.

The tips and templates area contains reminders and documents geared toward helping the user consider implementation issues during the design and development of materials. The tips page presents a (printable and editable) list of pointers, specifically generated for the user, based on the combination of answers regarding aims and context, such as this one: "Poorly qualified teachers who have been teaching for years have probably gotten used to using materials (like textbooks) to get them through. As a result, they probably know where to find content information. Offer them more generic tips on things to do in the classroom along with content-specific examples to help them learn how to apply those ideas." Each of the other pages (workshop, coaching and mass mailing) contains two types of information to support the execution of these implementation-furthering strategies. First, generic guidelines are given on how to carry out that kind of activity. Second, a tool is offered in the form of a template (sample workshop agenda, reflection form for coaching, or a custom-made cover letter for mailing). All of the documents in the profile section may be printed directly from CASCADE-SEA or exported for editing in a word processor.

Analysis

This component of the program helps users (usually facilitator teachers, working in small teams making lesson plans for larger groups of teachers within their region) to learn more about the needs and the context of the people who will use their lesson materials. It stimulates such consideration to increase the chance that the materials made will actually be beneficial to other teachers.



Box 4.6: Analysis component map

Box 4.6 shows the sections and areas within the analysis component. The analysis information section reminds users of the role of a needs and context analysis in the curriculum development process. In the questions section, users are encouraged to generate questions that will guide their analysis. These questions relate to those aims and context issues also found in the rationale. Here, the users are also reminded of those issues that are especially important for their own situation (places where they indicated uncertainty inside the rationale component) and encouraged to incorporate these into the analysis. By selecting relevant options within a series of check boxes, related analysis questions are automatically generated by CASCADE-SEA.

The strategies section encourages the user to consider how the analysis will be carried out, and offers three main approaches: classroom profile, policy synthesis, and perception poll. The classroom profile helps the user to gain a clear understanding of what is going on at the classroom level; this includes learning about what resources schools have and what they lack, as well as how teachers and learners are interacting in local schools. The policy synthesis entails reading, discussing and synthesizing professional thought on the curriculum (or related curricular innovations). Here, the focus is on the current research-based and policy issues that are relevant to the developers' project, including the items addressed in the national syllabus. Finally, the perception poll strategy gathers information on the main areas to be addressed in the lesson materials. In contrast to the policy synthesis, though, this is less geared toward the 'official agenda' and more aimed at finding out what people in the field want for their schools and regions. Basically, this strategy involves gathering a list of needs from teachers and headmasters as well as their related insights into their own context. The main idea behind the structure of these three strategies relates to the curriculum typology discussed in Chapter 2. By identifying any significant gaps that exists among formal curriculum (policy synthesis), perceived curriculum (perception poll) and operational curriculum (classroom profile), areas for improvement can be identified.

Based on the users' analysis questions, the CASCADE-SEA recommends certain strategies for selection. Once the user has selected which strategies will be used for answering the (usually multiple) analysis question(s), the computer encourages the user to define how each strategy will be applied. For example, in a classroom profile, information could be gathered in five different ways, through: classroom observation; document study; interviews; materials inventory; or questionnaires (see Figure 4.8).

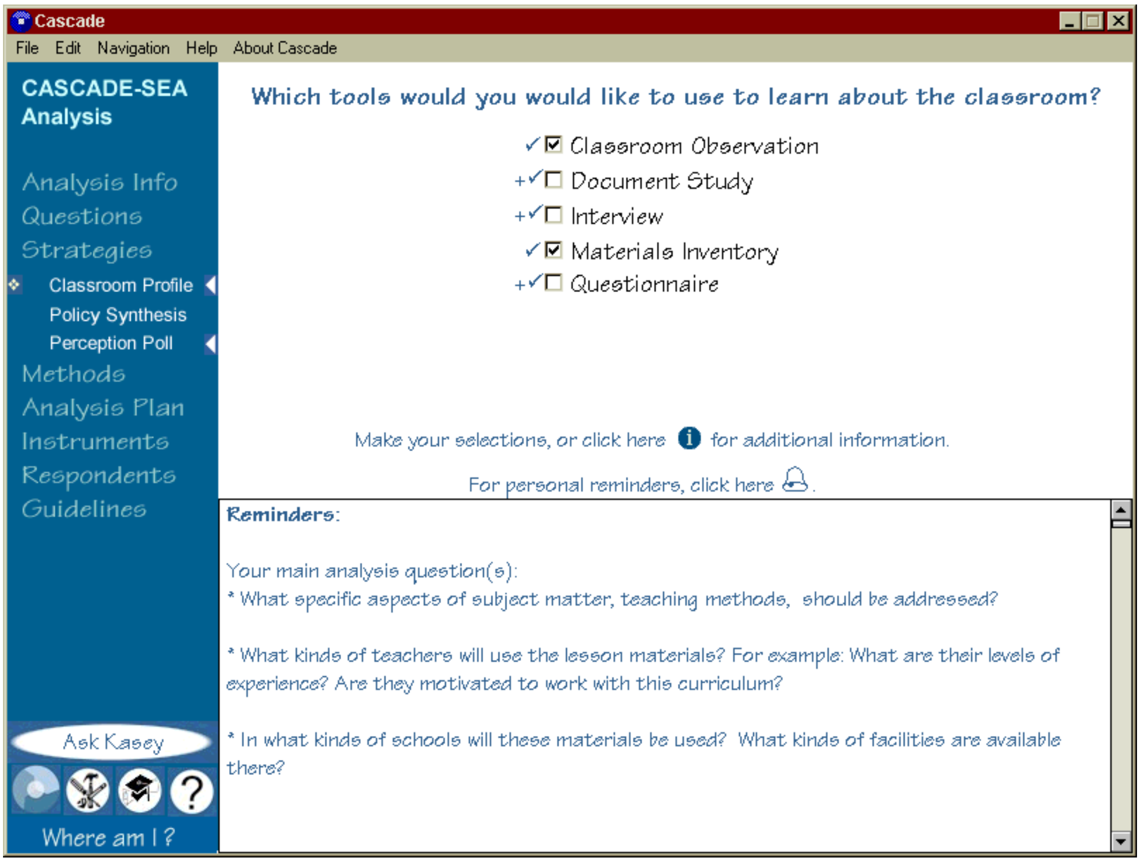


Figure 4.8: Final version (analysis screen)

Once the user has decided how each strategy will be approached, the methods section asks for further clarification on how this will take place. Here, the user is presented with a number of options as to how various activities could be conducted and asked for specification. For example, in conducting a classroom observation as part of the classroom profile, the user is asked to consider how many observers will be involved and what they should observe (small groups, large groups, entire classes etc.).

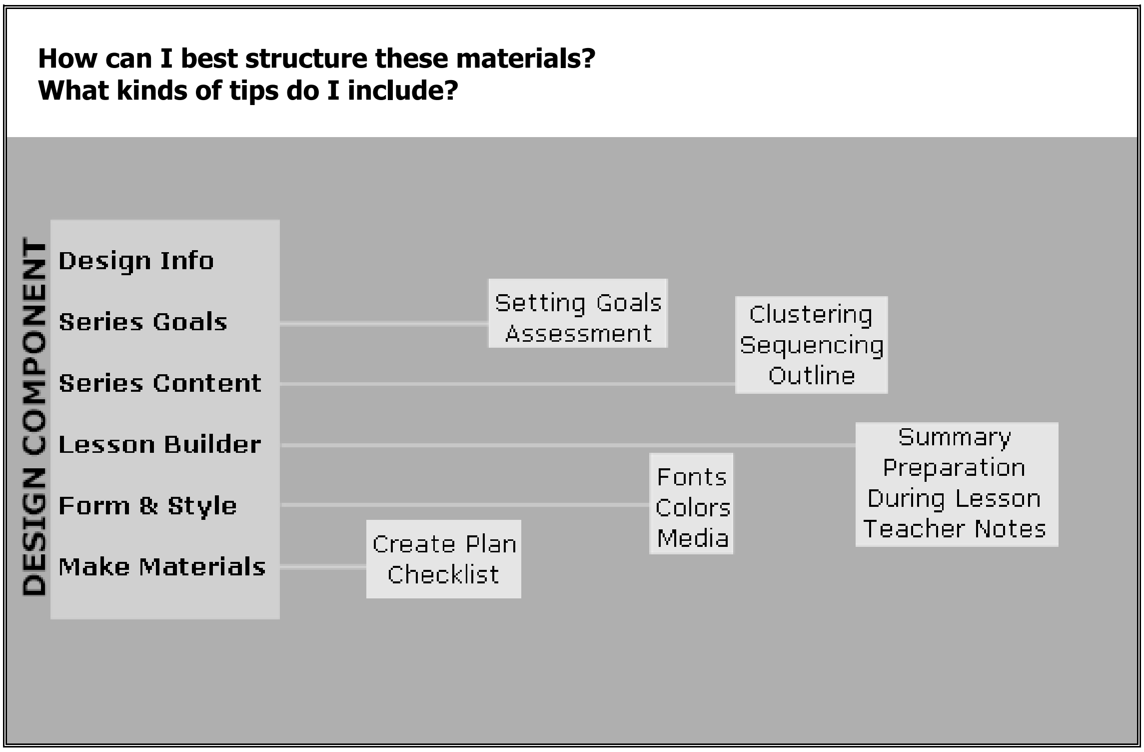
In the next section, the decisions made thus far are brought together in the form of a draft analysis plan. Clicking on the Create plan button causes the computer to generate a text document that summarizes the decisions made throughout the analysis section thus far, and puts them into a useful structure. As with most documents inside the CASCADE-SEA program, this plan may be printed directly or exported to a word processor for customization. CASCADE-SEA stresses the importance of tailoring the draft plans (for their own situation), and the checklist area offers the user a tool specifically designed to help with this task. The analysis plan checklist may also be printed or exported and guidelines for polishing the draft analysis plan.

The computer cannot (usually) accompany the user into the field to aid with a collection of analysis data. But the instruments section strives for reasonable approximation. In this section, users are provided with three kinds of tools to help them carry out their analysis: sample instruments, how-to guidelines and interpretation information. These tools are offered for each type of instrument available within the analysis component (observation schemes; document study schemes; interview schemes; literature review schemes; materials inventory schemes; and questionnaires). For example, the questionnaire area provides three sample questionnaires (one for the classroom profile, one for the policy synthesis and yet another for the perception poll) as well as information on how to administer a questionnaire and suggestions for interpreting the data collected through the questionnaire.

In a similar vein, the respondents section offers tips on selecting, contacting and interacting with various groups of respondents (headmasters, experts, teachers, learners, entire classes). Finally, the guidelines section offers possible approaches for handling ideas, suggestions, problems or comments which have been brought up during the analysis. These guidelines are divided into four areas: sources, priorities, overview and rationale. The sources area encourages users to consider the other sources of existing materials that may inspire or set a good example; it also suggests places where such materials might be found. The priorities area presents guidelines as well as a sample chart which may be used to compare and contrast the results of the analysis from different strategies. By doing this, the user can look for the most significant gaps between the desired situations than the existing reality. The overview section offers suggestions on how to organize the design guidelines generated through the analysis activities. Here too, an example chart is presented with suggestions on how to fill it in and how to use it in group discussions. Lastly, the rationale area reminds the user of the role of the rationale in the curriculum development process. It suggests returning to the rationale component to update any information, emphasizing that this can impact the way one goes about designing and evaluating materials.

Design

For those users who have an idea of what they would like to create, this component of the system offers support in designing and building paper-based lesson materials. It encourages (but does not require) users to build a lesson series, (in the form of a teacher guide). Users are free to choose between more and less structured designing approaches.



Box 4.7: Design component map

As shown in Box 4.7, this component contains six sections. The design information section describes the process that is supported in this component of the program. It reminds users that they are free to choose how much support they would like from the computer, and (for those who prefer to work more independently) how to export lesson templates and files. It also reminds them that they may work in any sequence they like, jumping around from one area/section to another as they see fit.

The series goals section of the program is divided into two main areas: setting goals and assessment. Having already considered the aims of the lesson materials in terms of how to support teachers (in the rationale), the setting goals area of the design component encourages users to think about what should be achieved by the learners. The user is asked to summarize the goals of lesson series by editing or replacing the sample goals provided. The sample entries are based on a synthesis of subject syllabi from the southern African region, such as the one denoted by italicized text here: "At the end of the lesson series, the learners will be able to: *Describe the basic hierarchy of structure and organization of living things; Explain how cells divide; Relate cellular structures to cellular function; Name some common characteristics and some differences between plant and animal cells.*" CASCADE-SEA then reminds the user, in the assessment area, that the series goals and assessment should be related and linked. Here, the program asks users to indicate how teachers should assess students during and/or after this lessons series.

The series content section is divided into three areas, intended to help users organize their goals (and related content) into lesson-sized chunks, and then to sequence these clusters to, ultimately, form an outline of the lesson series. The clustering area contains information about clustering, and guidelines or techniques that can be used (concept-, world-, inquiry-, learning- or utilization-related clustering). Further, this area provides a link to an external program (Mindman™) that assists with one of the most common forms of clustering goals: concept mapping. Clicking the Mindman button in this area of the program causes the external application to launch (CASCADE-SEA continues to run in the background) and one of 48 sample concept maps is opened (the sample is chosen by CASCADE-SEA based on the user's rationale information). The user may choose to ignore, discard, edit or keep this concept map. In a similar vein, the sequencing area provides information and guidelines on ways to sequence content. Finally, the outline area encourages the user to make a sketch of the lesson series (either via the Mindman program or through a word processing program) which will serve as a 'to do list' throughout the lesson building process.

After a framework has been established for the lesson series, the lesson builder section supports the construction of individual lesson plans. Often, small design teams work together up to this point and then divide the labor, working individually on the various lessons. The CASCADE-SEA program can keep track of a maximum of twelve lessons within a project. Additional files may easily be created by using the Save as function from the File pull-down menu, and creating a second volume of the project.

In the lesson builder section, four main areas are distinguished: summary; preparation; during lesson; and teacher notes. The summary section helps the user to produce a brief overview of the lesson so that the teacher using this guide will be able to obtain an 'at-a-glance' preview. This summary contains information on the timing of the lesson; the title and topic of the lesson; the way this lesson relates to others in this series; objectives; connections to a textbook (if any); and new or special words that will be introduced during this lesson. This last domain (vocabulary) features a database link, through which potential vocabulary entries are presented to the user (based on the information in the rationale component). In addition to entering one's own items, the user may browse through these entries, or search for additional words (accompanied by their definitions), adding them to the lesson plan with the click of a button. The words and definitions are then placed into an editable text field for further customization, if desired.

The preparation area of the lesson builder section is designed to help the materials developer create an overview of what the teacher needs to do and/or know before class begins. This includes listing materials that are needed to carry out the lesson, as well as any special preparation activities (e.g.: the mixing of solutions). Further, many teachers like to know what they can expect, especially when they use lesson ideas created by someone else. On the expectations page, users are encouraged to articulate common misconceptions and problematic areas pupils (may) have with regard to the concepts and/or activities addressed in this lesson, as well as any tips on how to deal with these.

The during lesson area is divided into five parts: introduction; lesson body; conclusion; homework and follow-up. The introduction page asks the user to consider reminding teachers to check homework and how this may be done. The lesson body page contains a link to a database with varying types of files that provide the building blocks of the lesson body: lesson activities; clips and equipment. While the users are free to contribute their own activities, clips and equipment, they may also browse or search through the files provided with CASCADE-SEA. Lesson activities range from generic activity descriptions (e.g. "Using Games for Teaching in Science Education") to topic-specific activities (e.g. "Purifying Muddy Water"), such as the one shown in Figure 4.9. The clip files contain media (mostly images) that may be used as illustrations in the lesson plans. And the equipment files offer suggestions on ways to improvise when resources are scarce (e.g. "How to Build a Simple Spirit Burner"). Entire lesson plans may also be accessed and integrated from this portion of the program, although users who seek completed plans tend to do so via the toolbox, instead (see toolbox description for additional information).

The conclusion page recommends that the materials designers suggest ways to reflect on this lesson as well as offer some sample questions that teachers could pose to pupils at the end of class. The homework page helps the user to specify how homework may (or should) be assigned, including another link to the database for homework ideas. Finally, the follow-up page encourages the user to consider how the teacher and/or learners might prepare for the next class.

The teacher notes area of the lesson builder section encourages the user to include additional tips (such as reminders of subject matter content) and information that might be useful to the teachers using these materials. Users may enter their own suggestions, or return to the database to find ideas to include (for example, from the generic activity files). Here, the user is also encouraged to visit the toolbox to make and/or add media to the notes section.

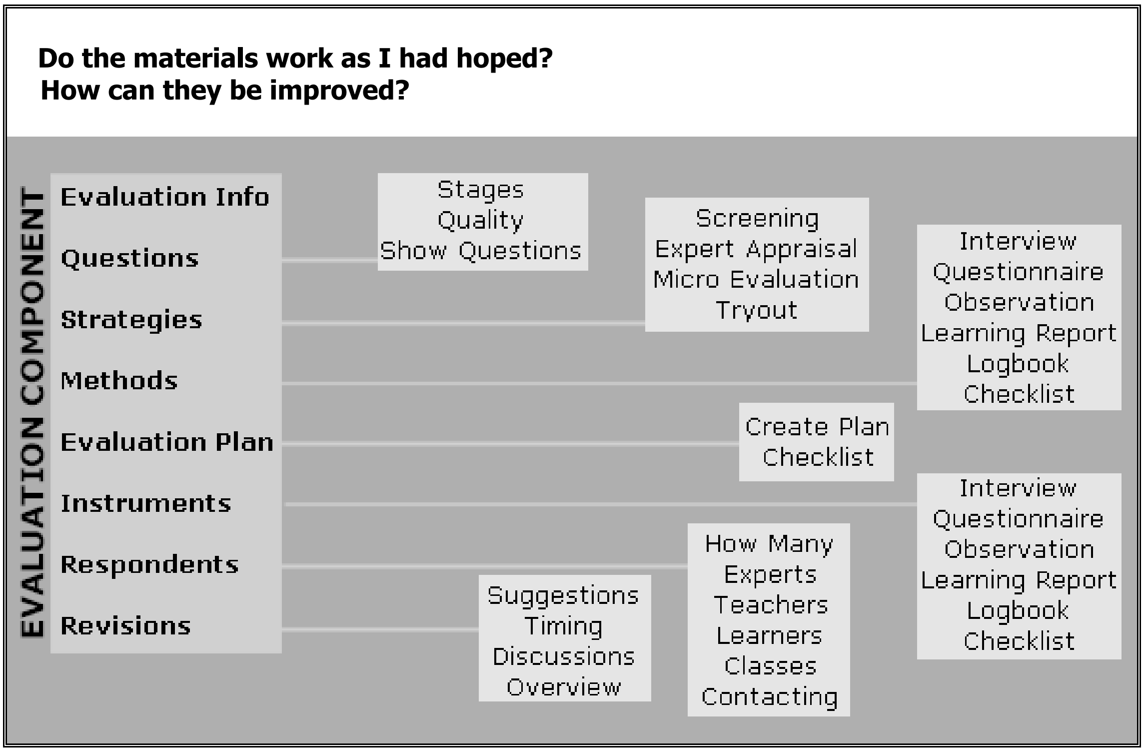
Figure 4.9: Final version (design screen)

The form and style section of the design component has been included to sensitize the user toward considering the overall tone that is purveyed through the fonts, colors and media used in the layout. The pages in this section offer some examples and choices in this regard, and users are encouraged to elaborate these aspects in their word processors.

In addition to information, the make materials section is divided into two areas. The Create plan button causes CASCADE-SEA to generate whichever lesson plan has been selected by the user. This plan is then presented inside the program window, along with the options to print and/or export the document to a word processor. CASCADE-SEA strongly encourages the user to recognize that this is a draft plan, in need of customization. Toward that end, the checklist page offers tips on how to do just that. In addition, a tutorial has also been dedicated to this process (for additional information, please refer to the tutorials description).

Evaluation

In this component, information about draft materials (or global ideas) is collected, analyzed and interpreted in a systematic manner, with the goal of determining how these items may be improved. As illustrated in Box 4.8, there are seven main sections (in addition to the evaluation information section) in the evaluation component. It bears a significant resemblance to the structure of the analysis component, due to the fact that both of these phases feature research activities. As the following text describes, the main difference between these two components is rooted in the questions asked, and the strategies used to answer them.



Box 4.8: Evaluation component map

In the questions section of the evaluation component, the user is encouraged to formulate a question to guide this process. CASCADE-SEA helps the user to do this by defining the stage of development (global outline, partial detail or complete) and then considering what quality aspects should be addressed in this evaluation. CASCADE-SEA recommends that the user consider the aspects of validity (being structured around relevant knowledge and scientific insights while also internally consistent); practicality (the teachers for whom the materials are intended can easily work with them as proposed); and effectiveness (learners and teachers experience the materials to be useful and the achieved results concur -to a certain extent- with the developers' intentions). After the user has made selections within the stages and quality areas, the questions area presents pre-formatted evaluation questions to the user. Additionally, the recommendation is made to elaborate these questions (in the form of sub-questions).

The strategies section supports the user in determining how to answer the main evaluation questions. In this portion of the program, CASCADE-SEA presents four strategies as well as recommendations as to which one(s) would be most suitable for the individual user's situation. The strategies are: screening; expert appraisal; micro-evaluation; and tryout. The screening evaluation strategy involves a comparison by the developer in which the material created is compared and contrasted with a checklist of desired characteristics. In an expert appraisal, the developer(s) ask(s) one or more experts for commentary on the material. The micro-evaluation and tryout strategies both involve testing the materials. Where as the micro-evaluation strategy is used by a small group of students and/or teachers outside of the normal classroom situation, the tryout strategy means that the material will be tested by teachers and students in a normal classroom situation. Once the user has determined which strategies will be used to answer the main evaluation questions, CASCADE-SEA asks for additional clarification in terms of how the strategies will be carried out (i.e. through interviews, questionnaires, observations, learning reports, logbooks or checklists).

In the methods section of the evaluation component, users are reminded of the choices that they have made regarding how to carry out each strategy, and then asked for further clarification in terms of the situation in which these activities will be take place. For example, the user is asked to consider how many people will conduct interviews during a micro-evaluation, and in what kind of setting this will take place: individually; in pairs; in small groups; in large groups; or with entire classes.

In the next section of the program, CASCADE-SEA provides users with a draft evaluation plan as well as the recommendation to customize it for their own specific situation. The create plan area features the draft evaluation plan created by CASCADE-SEA, based on the choices made in this component. This is presented, along with the option to print it directly or to export this plan to a word processor for editing and customization. The checklist area contains specific information on how the users may go through their plan and make changes (in their work processors) to tailor it for their specific situations. As with most documents within CASCADE-SEA, these too may be printed directly from the screen or exported for editing.

As illustrated in Figure 4.10 (next page), CASCADE-SEA provides (some) support the user in actually conducting the evaluation activities. Sample instruments are given for various respondent groups, tips are offered for how to conduct that kind of activity and guidelines are presented for interpreting the data generated.

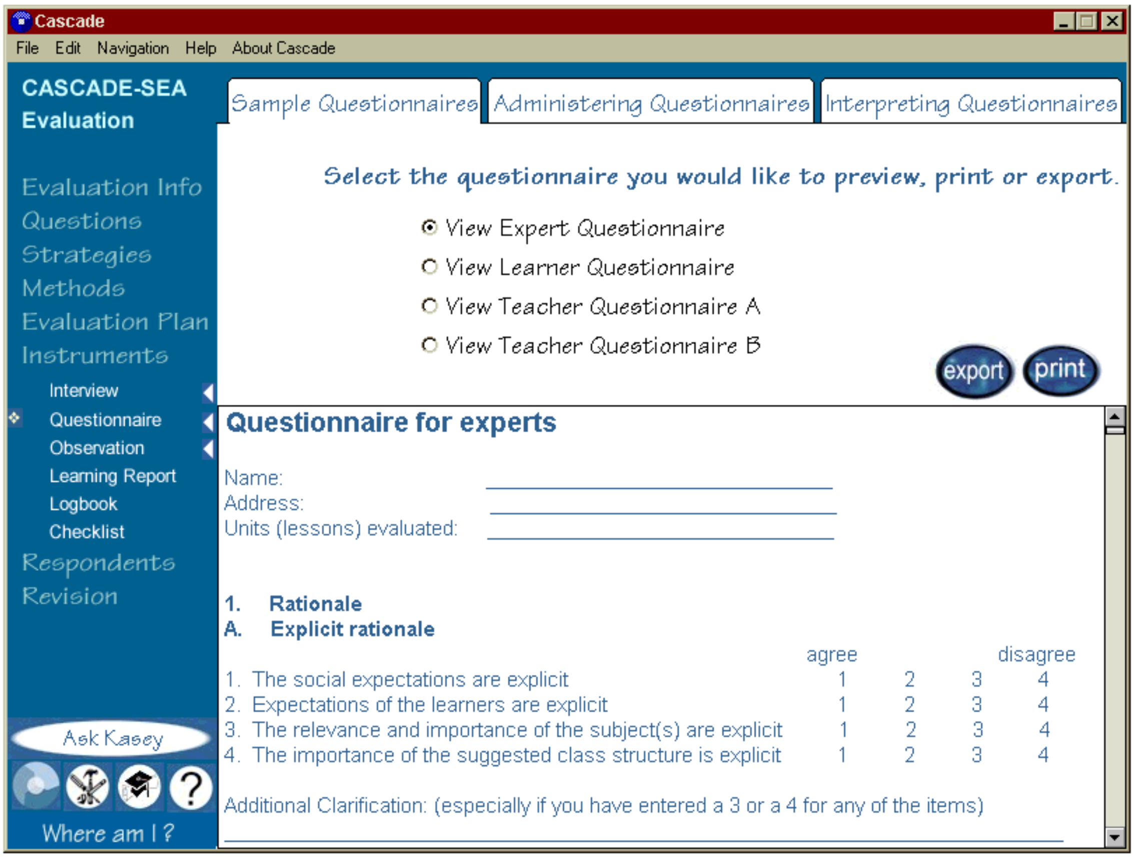


Figure 4.10: Final version (evaluation screen)

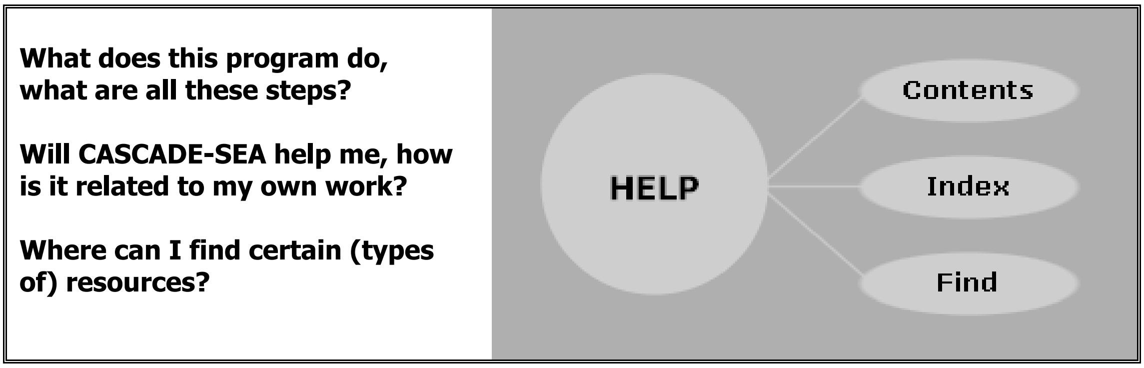
The respondents section is composed of six areas designed to assist the user in determining how many respondents should be included; how to approach and select experts; how to determine which teachers to involve in an evaluation; choosing learners to participate; selecting classes; and contacting respondents. In each of these areas, CASCADE-SEA presents documents with tips and suggestions on what to do. These documents may be exported and edited or combined. In this way, a small design team may articulate their own guidelines for this and future evaluations.

The last section in the evaluation component provides support for generating a revision proposal, offering possible solutions for problems or points for discussion brought up during the formative evaluation. The suggestions area offers guidelines for generating revision suggestions. The timing area assists the user in determining which decisions should be made immediately, which ones should be postponed and which problems are not worth solving. Materials developers are urged to consider complex problems related to their materials in the discussion area. And finally, users are advised to organize the revisions in a manner that will provide guidelines for future activities. The overview area offers an approach to present clear, concise revision decisions through the use of a chart.

Additional Features

Help

The CASCADE-SEA program employs standard Windows help functions, with three main parts: contents, index and find (see Box 4.9). All help files (accessed through any section) may be printed, annotated (the user may jot notes for future reference), copied to the clipboard and/or bookmarked (for easy return). In addition, the help display may be customized to viewer preferences.



Box 4.9: Help component map

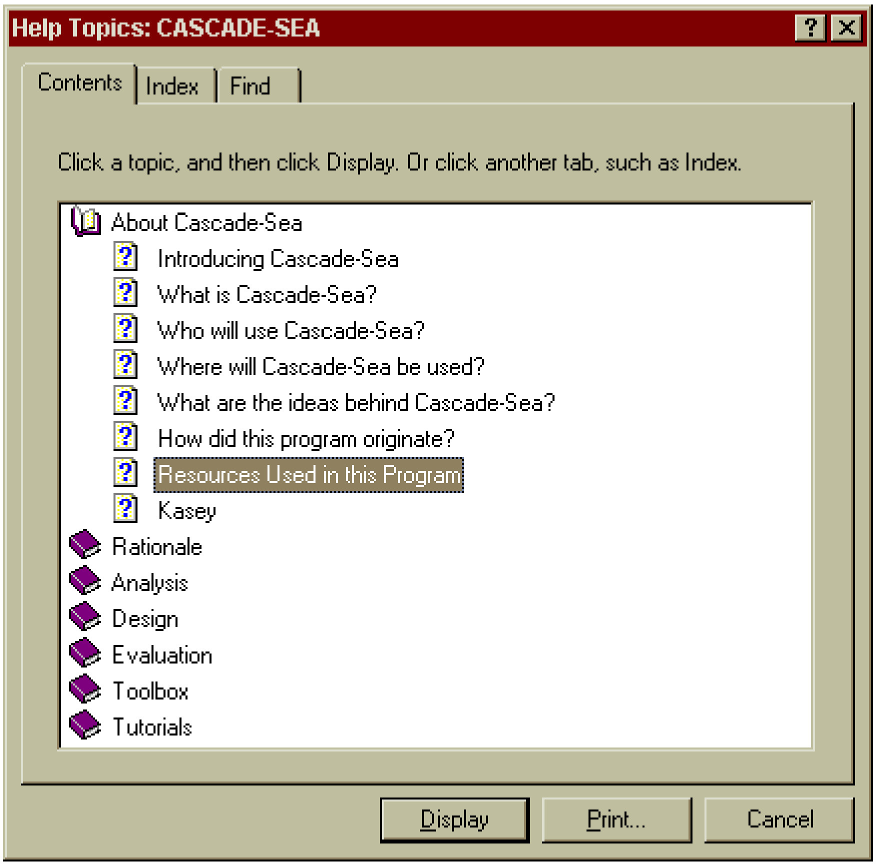


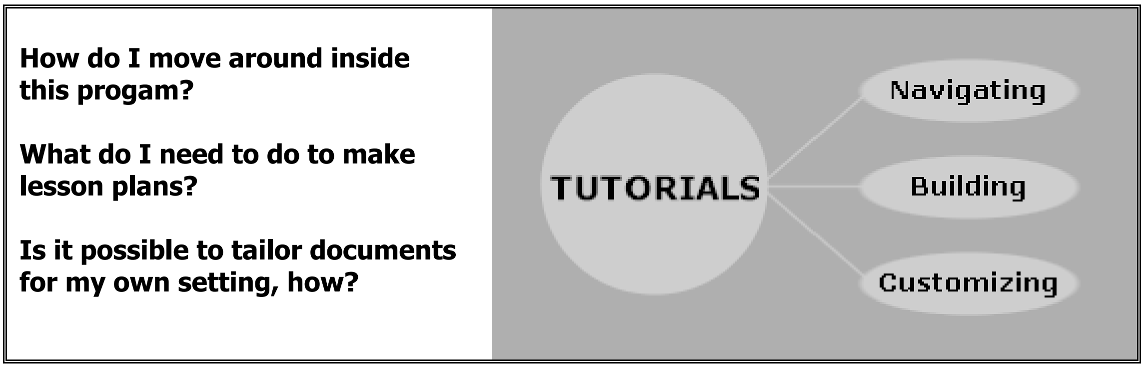
Figure 4.11: Final version (help screen)

As illustrated in Figure 4.11, the contents section offers answers to some of the most frequently asked questions regarding the program. It also provides step by step guidelines on how to work with the rationale, analysis, design and evaluation, toolbox and tutorials components.

The index section allows the user to look up information based on keywords (already identified by CASCADE-SEA), whereas the find section looks for the user's entry (in all help files), and presents any topics that contain that word (or phrase).

Tutorials

CASCADE-SEA helps newcomers learn how to use the program by offering tutorials on three main subjects: navigating inside the program, building materials for the first time and customizing the drafts that are generated by the computer (see Box 4.10).



Box 4.10: Tutorials component map

These tutorials are linear presentations geared toward a brief introduction to the topic. For example, the navigation tutorial (Figure 4.12) consists of eight screens, and usually takes about five minutes to complete.

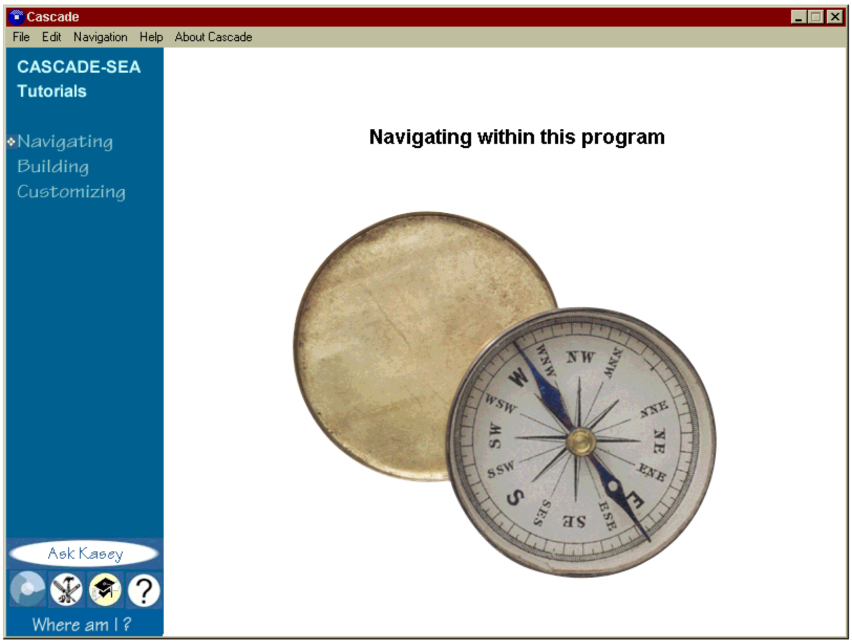
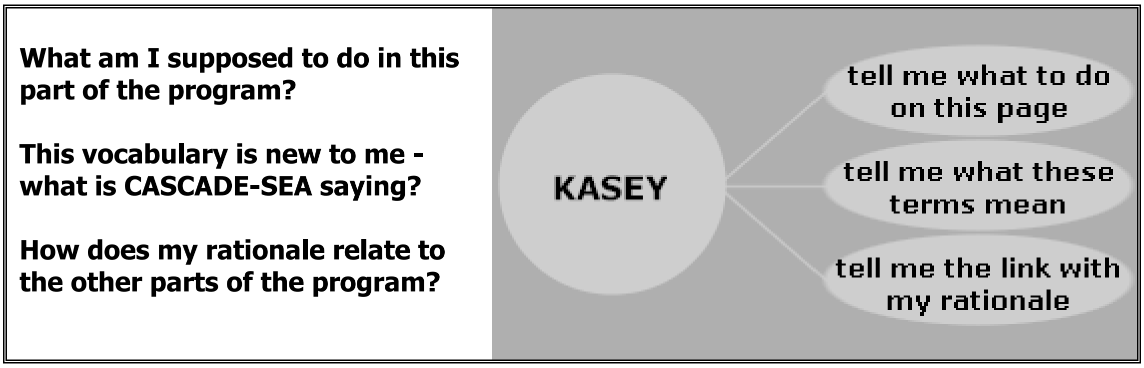


Figure 4.12: Final version (tutorials screen)

Kasey

Another form of assistance that is available throughout the program is Kasey. This little androgynous bird is the voice of CASCADE-SEA, offering context-sensitive information about each page, tips on what to do and how certain activities relate to other parts of the program (see Box 4.11).



Box 4.11: Kasey component map

Kasey's existence was born out of two main concerns. First, it has been noted, both throughout this study as well as in others, that people do not readily access help functions. Rather, they prefer to consult more personal 'buddies' such as colleagues. Although this program has been designed for use in settings where real buddies are likely to be available (teachers collaborating in TRCs), the system also contains an 'e-buddy' alternative. Kasey comes in a more friendly looking package than standard help (the little bird shown in Figure 4.13 appealed to most users), and offers the user context-sensitive assistance. In addition to helping the user with the current task, this approach eliminates the need to leave the current work screen for help, and risk losing one's place in the program.

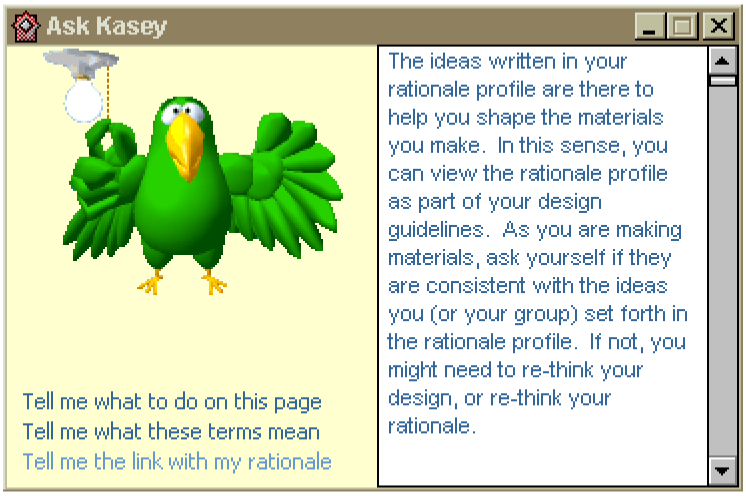
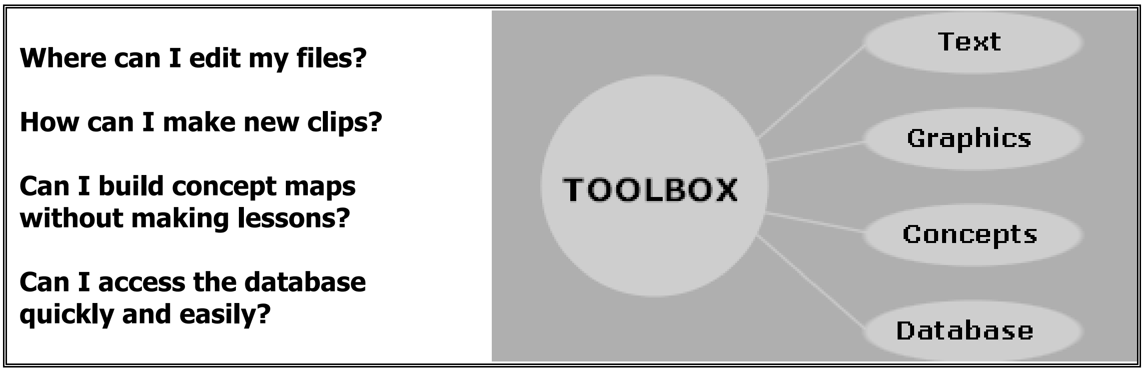


Figure 4.13: Final Version (Kasey screen)

Secondly, the developers considered it important to support users in maintaining a focus on their rationale while involved with other parts of the program. To a certain extent, such functionality is integrated in the analysis, design and evaluation components themselves. However, Kasey enhances this functionality by providing the user with the opportunity to either reflect on the choices made in the rationale section (without leaving the current location), or obtain advice on how to proceed (based on the choices made in the rationale section), without leaving the current location.

Toolbox

The toolbox offers ways to help the user customize and elaborate the plans that have been made. Such tools are divided into four categories: text, graphics, concept mapping and database, as shown in Box 4.12.



Box 4.12: Toolbox component map

The text section offers a link to a word processor that may be used for editing documents generated by CASCADE-SEA, or for creating additional documents, such as learner handouts. The graphics section of the toolbox provides links to two drawing programs, for users who would like to create their own illustrations. Because the concept mapping process is considered useful not only for designing a lesson series, but also for general brainstorming or group planning, a link to the Mindman program is provided from this location for easy access. Finally, users who would like to visit the database without designing lessons may do so directly from the toolbox (as shown in Figure 4.14). They have access to the same database files

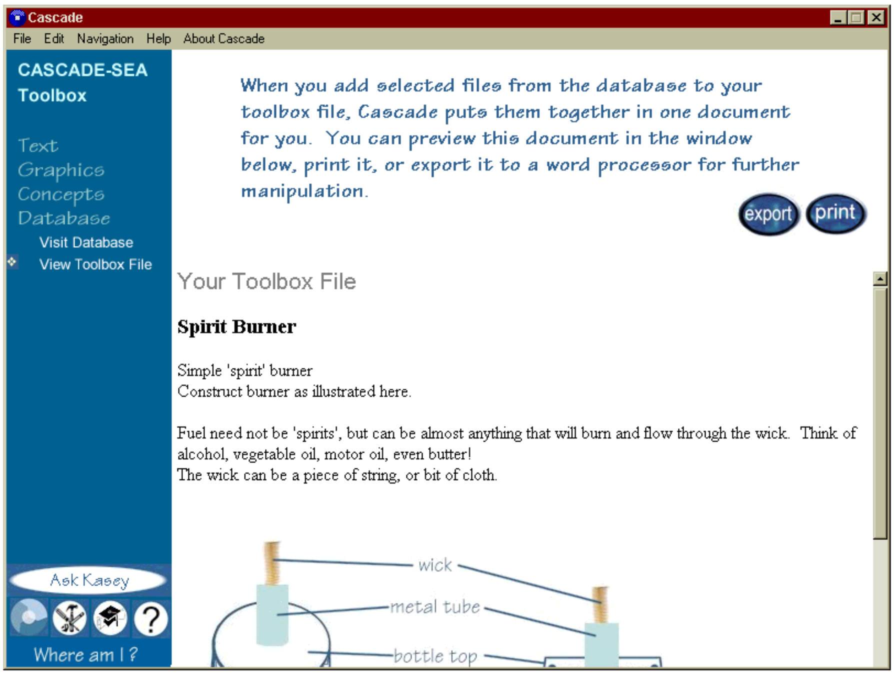


Figure 4.14: Final version (toolbox screen)

(complete lesson plans, lesson activities, clips and equipment ideas) that are found elsewhere in the program. The difference here is that, when selected, these files are put into an independent document called the "Toolbox File" and not integrated into a lesson plan.

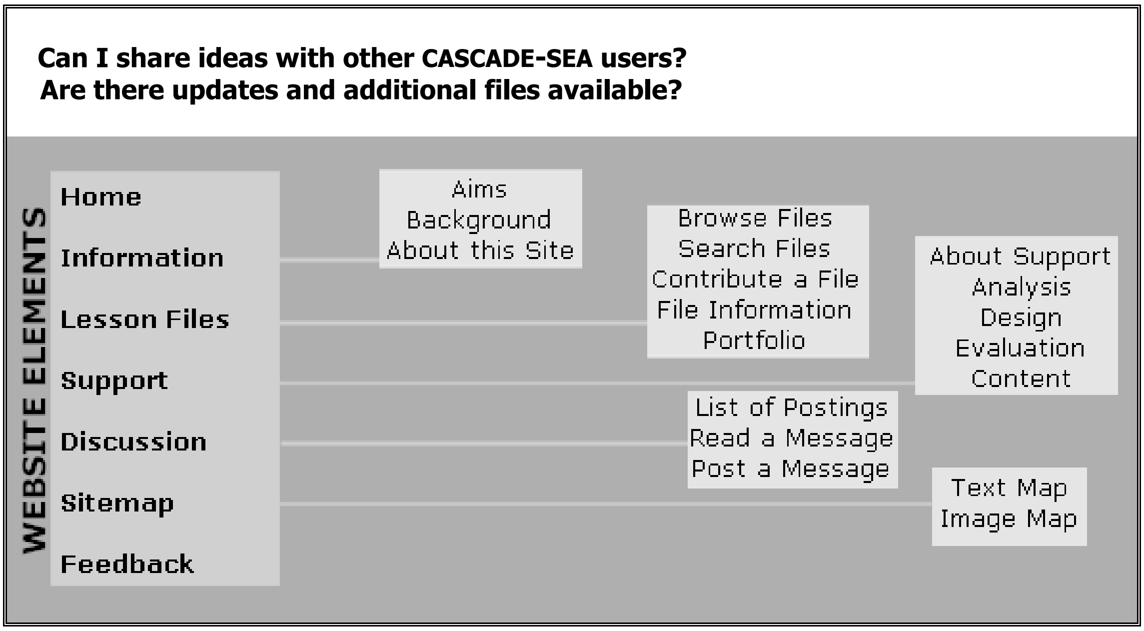
One of the main ideas behind the toolbox feature is based on the fact that most users of the system are not only new to CASCADE-SEA, but to computers in general. While many users enjoy learning new skills, such a process can be intimidating. Through this feature, it is hoped that users will become familiar with the CASCADE-SEA 'suite' of tools, thus learning how to work with multiple programs while still connected to the familiar environment of CASCADE-SEA. In a similar vein, it was considered important for CASCADE-SEA to provide the basic ingredients necessary for working with it according to the designers' intentions. For example, the program consistently emphasizes the need to view and then customize documents in a word processor. Although nearly all of the computers running CASCADE-SEA contain such software, it was considered be irresponsible not to provide a solution for those who do not. Hence, the text section of the toolbox was created to offer a simple, but effective word processing program. For those who are fortunate to be working in a setting where more advanced software is available (and, more importantly so is the training to learn how to use it) the text and graphics features are likely to be ignored.

4.5.2 Content: Website

Although the number of CASCADE-SEA users with Internet access is rapidly increasing, many still work with the system in an off-line setting. For this reason, the website was conceived as a supplement to (and not a constituent part of) the main program. It supports that to which the Internet is extremely well-suited: communication. Whereas the CD-ROM aids the materials designer in making personal decisions about how to create a series of lesson plans (a teacher guide), the website aims to foster communication between materials designers.

As illustrated in Box 4.13, the website consists of six main sections, in addition to the home page. The home page provides news and recent update information, as well as information of what may be found in each area of the site. The information pages describe what this site is, its aims, and offers background information. The lesson files pages connect the user to an online database of resources, divided into six categories: complete plans, topic-specific activities, generic activities, vocabulary, and improvisation of equipment and clip art. Users may browse (see Figure 4.14) or search through these resources for their own purposes, or contribute files to the complete lesson plans, topic specific activities or generic activities categories. The portfolio function allows users to mark interesting entries in the database for later retrieval.

The support area of the website offers a taste of the guidance that may be obtained from the CD-ROM (but lacks the degree of depth and interactivity). Here, basic information and resources are offered for structuring the curriculum development process in general, and in particular: conducting needs/context analysis; designing materials; carrying out a formative evaluation and obtaining subject-matter support for the content addressed.



Box 4.13: Web elements map

The discussion area was established to offer materials developers an opportunity to communicate directly. In addition to fostering a sense of 'esprit de corps,' this is intended to serve as a place where developers may enlist the aid of their colleagues (e.g. "I'm looking for a nice illustration of the evaporation process, does anyone have something I might use?") or post their expertise (e.g. "I just completed a new set of lessons on genetics. Mail me if you'd like a copy.") The sitemap offers two overviews of the entire site contents: verbally and graphically, for quick jumps to any page. Finally, the feedback link generates an email message which may be sent to the CASCADE-SEA primary developer (of both the website and the program), to enable visitors to share their comments, questions or suggestions.

Figure 4.15: Final version (support website) at Http://projects.edte.utwente.nl/cascade/seasite/

4.5.3 Support offered: CD-ROM and website

Sections 4.5.1 and 4.5.2 described the program and website features, with an emphasis (although not exclusively so) on the content addressed. For additional clarification, the Table 4.4 (below) illustrates the various types of support components that may be found within the final version of the CASCADE-SEA program, based on the guidelines presented in section 4.2.2.

		Functions	**Guidelines:** CASCADE-SEA Examples *from CD-ROM and website*
Advice	*Tailor-made*	Provides warning of consequences Helps identify/set goals and priorities Feedback may be proactive/reactive	**Reminders:** Checkmarks indicate the instruments a user will need for the analysis or evaluation activities selected **(Consistency) checks:** Illogical steps/options are visible, but disabled **Heuristics:** Design ideas in the rationale tips section are based on combinations of user input selections
	Generic tips	Best practices Predictions Decision making support	**Literature lists:** Help files contain literature sources used for each component **Examples/cases:** Completed mind maps with lesson series content are offered to the user in the design area **Heuristics:** Printable suggestions are offered for how to carry out analysis or evaluation data collection **Sample choices:** Default (sample) goals are pre-loaded into the user's text entry field in the design section, based on the subject and topic selected in the rationale
Tools	*Internal*	Prepares (sub)tasks for execution Automates (sub)task execution Summarizes user actions	**Templates:** Instruments are offered to be used as is, or altered (including suggestions for customization) **Checklists:** Improvement checklists are offered to the user after drafting analysis, evaluation and lesson plans **(Flow) charts/Option trees:** Decision and discussion charts are offered at the end of the analysis and evaluation components **Auto-complete/check/correct/:** CASCADE-SEA warns users who are about to replace existing documents **Auto-save/archive/copy:** CASCADE-SEA automatically saves user records every 10 minutes to the archival structure defined at the start of a project; any time a user opens a (new) document from within the program, their own copy is automatically generated in their project folder (archives) **Generates (draft) products:** Creates a rationale profile plus analysis, evaluation and lesson plans **Note-taking/personal reminders:** Message box appears with personal suggestions (based on user input) when user generates rationale profile **Histories (navigation, use, time, etc.):** Recent pages navigation via pull-down menu (top bar)

Table 4.4: Support components in CASCADE-SEA (continued on next page)

		Functions	Guidelines: CASCADE-SEA Examples *from CD-ROM and website*
Tools	*External*	Extends (sub)tasks Links to related (sub)tasks	**Programs:** CASCADE-SEA's toolbox includes external programs for drawing, editing text and creating mind (concept) maps **Information:** The CASCADE-SEA support website contains links to other useful sites relating to components of curriculum development and subject matter content **Data:** The CASCADE-SEA support website contains links to additional databases with lesson activities
Learning opportunities	*Implicit*	Advanced organization Matches the desired flow of work	**Visual appearance suggests a method for doing (sub)tasks:** The main menu and sub-screens do this **Previews:** CASCADE-SEA offers users a chance to see any/all documents before deciding whether or not to export them to a word processor for editing **Sequencing:** A logical sequence is structured vertically in the navigation bar (working top to bottom) **Metaphors:** Kasey signifies the voice of CASCADE-SEA **Monitoring:** Recommendations for analysis and evaluation approaches are based on user input
	Explicit	Answers (procedural or conceptual) questions (who, what, when, where, how, why)	**Demonstration:** Navigation tutorial shows how to move around the program (including animated cursor) **Evaluation:** Inconsistent answers are not allowed in certain areas **Explanations:** Extra information located behind ⓘ buttons on most pages **Instructions:** Top of each page tells the user what to do there **Illustrations:** Where am I? button shows program map, with current user location is circled in red **Samples/cases:** Implementation tips offer sample documents (workshop agenda, coaching form, mailing tips) plus information on how to use them
Communication aids	*Written (real-time or asynchronous)*	Facilitates internal communication (with individual colleagues or [parts of] the organization) Links to outside expertise	**Shared knowledge/database:** Database of lesson plans, activities, clips and equipment grows as users contribute **Websites:** the CASCADE-SEA website offers an extension of the program, as well as links relevant sites **Bulletin boards:** CASCADE-SEA offers a bulletin-board style discussion group **List Servs/Chat rooms:** Although the CASCADE-SEA website does not offer these features, some of the linked sites (on these pages) do
	Verbal	Fosters reflection Stimulates discussion/debate Provides or provokes coaching	**Checklists:** Analysis section guidelines area includes checklist for working in teams **Examples:** Position statements in the values area of rationale aim to stimulate group discussion **Instructions:** Design teams encouraged to discuss their 'to do' list between structuring content and building lessons

Table 4.4: Support components in CASCADE-SEA

4.5.4 Interface and technical descriptions: CD-ROM and website

Screen shots from the CD-ROM and website have already shown what these elements look like, in varying program locations. Table 4.5 below illustrates how the development guidelines listed in section 4.2.3 were ultimately implemented in the CASCADE-SEA program. Since this table is for illustration purposes only, no attempt is made to provide a comprehensive list of each interface aspect; rather, one example has been selected for each main idea.

	Guidelines	**Examples from the CD-ROM and website**
User in control	Tasks may be automated, but the user (not the software) initiates actions.	When the user clicks on the Export button (located on any page where documents may be seen), the document is then copied to the user's own folder and opened from there, so that all work will be saved in a convenient location.
	Users must be able to personalize aspects of the interface and should be as interactive and as responsive as possible.	Users may determine how much (or how little) information is displayed on a page by toggling information text and reminder cues on and off.
	Provide exits and shortcuts.	Multi-level navigation exists with main component areas; user can navigate to exit, main menu, help, tutorials and other components (main pages) from any page.
Directness	Interface should be task-oriented (toward achieving desired goals).	Main menu represents navigational structure as well as a method for completing the task simultaneously; the user decides where/when to begin.
	Users should be able to directly manipulate (representations of) information.	Selected verbs in the objectives section (of design) are immediately copied into the editable text box when the Paste Word button is clicked.
	Visual information and choices reduce mental workload, and metaphors are often intuitive ways of doing this.	Many screens structure the task by presenting the most relevant options; the user need only make selections.
	Navigation and actions (e.g. selection options) should be clear.	Indicator marks the user's current location within a component; to see the user's current location with reference to the entire program, the Where am I? button is available on every page.
Consistency	Provide stability by making the user interface as familiar and predictable as possible.	Each area of the program is built up in a similar structure (although some components go 'deeper' than others)
	Consider consistency within an application, an operating environment, and within a metaphor.	Pull-down menus feature typical Windows commands in predictable locations (e.g. File/Save, Edit/Copy).

Table 4.5: Interface aspects addressed in CASCADE-SEA *(continued on next page)*

	Guidelines	Examples from the CD-ROM and website
Consistency	The system should be reliable in advice and performance.	Recommendations are based on carefully structured guidelines (section 4.2.1).
	Screen zones should remain constant (information areas, interaction areas, tool areas, etc.).	Screen layout is the same throughout the program; navigation, information and action zones do not change.
Forgiveness	Minimize errors (and the need to correct them).	If the user tries to proceed to a location in the program with a logical pre-requisite, the action areas are visible, but inactive (grey). Clicking on the inactive buttons yields an explanation as to what must be done in order to enable that section.
	Allow for interactive discovery (trial and error) by providing warnings where potential mistakes may occur.	The system asks the user to confirm exiting, replacing documents, etc.
	Accommodate for both physical and mental mistakes by making recoveries easy.	Bumps of the mouse or keyboard that accidentally send the user into another area of the program can be reversed by using the recent pages feature.
Feedback	Provide appropriate, immediate feedback for user actions.	Button states change immediately to show the result of user actions (e.g. boxes are checked).
	Avoid unresponsive ('dead') screens.	When the system needs to process long calculations (such as generating a draft lesson plan), an hourglass appears to indicate that they system is busy.
Aesthetics	Communicate important cues about system behavior while remembering that screen elements compete with each other for the user's attention.	The same buttons are used perpetually throughout the program. This way, new (non-perpetual) items on the screen tend to grab the user's attention more, and focus them on the task at hand.
	Use concise text and images, only functional elements (to inform, not impress).	Text buttons are limited in length, perpetual navigation features are offered in icons (lower left of screen) or through pull-down menus (stowed in the toolbar until needed).
Simplicity	Strive for a balance between simplicity (easy to learn, easy to use) and functionality.	This program is designed to be introduced in a professional development program (not to be self-teaching). Having had a basic introduction, users need only a short period of time to be re-acqainted.
	Reduce clutter by building on the user's existing knowledge and by progressive disclosure (show only relevant information for certain tasks, not all information for all tasks).	Variable display density plus specially tailored instructions on each page reduce clutter.

Table 4.5: Interface aspects addressed in CASCADE-SEA

This chapter has presented the results of the study in terms of the characteristics of a system that is deemed valid and practical while having the potential to impact the performance of (resource) teachers in the creation of exemplary lesson materials for secondary level science and mathematics education in southern Africa. (For a discussion on the *degree* of validity, practicality and impact potential, please refer to Chapter 6.) These characteristics have been defined in three layers of detail: broad (foundational tenets), general (development guidelines) and specific (product specifications). Each layer has addressed the areas of content, support and interface (including technical) issues.

The characteristics presented in this chapter were derived from the circuits of data collection activity, mentioned in Chapter 3. Deeper insight into these activities will thus allow for increased understanding of the design decisions made. Hence, with the exception of the literature review (already presented in Chapter 2), Chapter 5 presents the results from the 34 data collection circuits that comprised the CASCADE-SEA expedition.

Chapter 5

Results of the expedition

Data collected throughout the CASCADE-SEA study were often analyzed twice: immediately after the data collection activities took place (to inform the following decisions), and at the end of the data collection period (to gain an overall perspective). Both procedures involved the techniques described in Chapter 3. While results of the initial evaluations were presented by way of the prototype descriptions in Chapter 4, this chapter discusses the results of data analysis with regard to the study as a whole. The data are presented according to the three main phases of the study: needs and context analysis; design development and formative evaluation of prototypes; and semi-summative evaluation. From the different perspectives of each phase, the three areas of validity, practicality and impact potential are examined. The chapter concludes by describing how these findings contributed to the evolution of the CASCADE-SEA program.

Chapter 3 (section 3.5) described the data analysis procedures that were used during this study. This description includes the creation of data summaries containing separate sections for content, support and interface issues. Arranged together, these (condensed, analyzed) data summaries portray the results of the CASCADE-SEA exploration as they relate to both the main research questions and the various research circuits (data collection activities). The complete summaries matrix forms the foundation of this chapter.

These documents (187 summaries) are located on the CD-ROM at the back of this book (see Appendix H). In addition to the color-coded (condensed) data themselves, each summary includes: a brief description of the related circuit's activities; the data sources used in each circuit; those sources used for that particular summary; data weight before research activities were conducted and the data weight after the activities took place. For an overall picture of how each data source (within the various circuits) contributed to the study as a whole, please refer to Appendix I (Instruments and questions matrix).

As stated, the data presented in this chapter have been reduced and grouped according to the phase of research and the research questions. To assist the reader in identifying the sources of data being discussed throughout the chapter, Table 5.1 illustrates the clustering and sequence in which data are presented. The numbers in the cells indicate the order of presentation in this chapter. These numbers are also included in the section headers throughout the chapter for easy reference. As one can see, conclusions and implications are addressed three times; this is because each phase examines the quality characteristics from slightly different perspectives.

		Cycle and related circuits	Data Typology						
			Validity		Practicality			Impact	
			SAK	*INC*	*INS*	*CON*	*COS*	*BQM*	*EPD*
Section 5.1	**Needs and context analysis**	*Concept validation** Circuits 1-4	1	3	6	8	10	(no relevant data collected)	
		Site visits (discussion tool) Circuits 5-7	2	4	7	9	11		
		Conclusions and implications based on analysis results	5		12				
Section 5.2	**Design, development and formative evaluation of prototypes**	*Prototype 1* Circuits 8-11	13	17	22	26	30		
		Prototype 2 Circuits 12-14	14	18	23	27	31	35	38
		Prototype 3 Circuits 15-24	15	19	24	28	32	36	39
		Prototype 4 Circuits 25-30	16	20	25	29	33	37	40
		Conclusions and implications based on design results	21		34			41	
Section 5.3	**Semi-summative evaluation**	*Final evaluation* Circuits 31-33	42	44	47	49	51	54	56
		Query Circuit 34	43	45	48	50	52	55	57
		Conclusions and implications based on evaluation results	46		53			58	

Table 5.1: Data presentation sequence and grouping

Legend
* = Literature review results were presented in Chapter 2; thus, they are excluded here
Validity: SAK=state-of-the-art knowledge; INC=internal consistency
Practicality: INS=instrumentality; CON=congruency; COS=cost
Impact: BQM=better quality materials; EPD=enhances professional development

Due to the sheer volume of data collected during this study, the presentation outline shown in Table 5.1 is intended to clarify the structure of the chapter. It should be noted however, that the distinctions made in this table may appear more clearly drawn than actually was the case during the study. In an effort to increase clarity and decrease redundancies, data were classified (during data analysis) according to the *most*, but not the *only*, relevant relationship to the quality aspects. The fact remains that much of the data collected did relate to more than one column in the data typology, simultaneously. The same holds true for the distinctions made throughout this chapter. To some extent, they are arbitrary. While such 'tidy little packages' (of data) are preferred to facilitate discussion, they should not be misconstrued as representative of a simplistic view. For further discussion of the merits and faults associated with sharpening these naturally-blurred distinctions, please refer to Chapter 6. Throughout this chapter, footnote reminders of quality criteria definitions (pertaining to content, support and interface issues) are offered when these topics are initially introduced. For complete descriptions of these aspects, please refer to Table 3.1.

The results presented in this chapter synopsize the large quantities of data contained in the aforementioned data summaries. Additional information regarding each area of discussion may be found by locating the appropriate cell number from Table 5.1 (excluding grey cells) and then referencing the corresponding data summaries in Appendix H. For example, in the section entitled, "Concept validation cycle results (state-of-the-art knowledge: 1)" the numeral 1 corresponds to Cell 1 of Table 5.1. This cell is located at the intersection of state-of-the-art knowledge (a sub-aspect of validity) pertaining to the concept validation cycle (circuits one through four). The contents of this cell (as illustrated in Table H.1, Appendix H) are data summary documents: SAK1, SAK2, SAK3, and SAK4. These documents are contained on the CD-ROM located at the back of this book (for further clarification, see Appendix H).

Finally, the need to condense data for its presentation in this chapter prompted a number of reporting decisions regarding how to responsibly determine what to include and what to exclude. These decisions were eventually based on three types of guidelines, pertaining to: weight, frequency and repetition. As discussed in section 3.4, individual circuit contributions varied in terms of the usefulness of results. The researcher's perception of this variation is represented in Table 3.3, through grey-scale shading (lighter boxes show lower contributions, while darker boxes illustrate high contributions). These weights are based on the *salience* and *intensity* of the data collected, and not necessarily on the volume. Hence, one reporting guideline has been to include data from (at least) those circuits with medium to high data weight. However, Nieveen (1997) comments on the need to weigh off both salience and frequency of remarks offered by participants. Toward offering the reader the opportunity to do this, another guideline has been to include (and clearly indicate) feedback that was offered by various participants across circuits and cycles (regardless of data weight). Lastly, toward minimizing volume and redundancies, once such patterns emerged, comments that were repeated across cycles are described in detail the first time they are reported. After that, similar remarks are noted as such, but extended treatment of the topic is not offered unless new aspects, insights or perspectives are involved.

5.1 Analysis: What to make?

As previously mentioned, the primary goal of the analysis phase was to obtain a working knowledge of the target setting, user group and areas in which a support tool may be put to work. In addition to launching a study of relevant literature (discussed in Chapter 2), concept validation and site visits took place. The concept validation cycle was composed of four activity circuits (with participants from Netherlands, Lesotho, Tanzania and Zimbabwe); and the site visit cycle was composed of three circuits (with visits to South Africa, Botswana and Tanzania). During the expert appraisals and micro-evaluations carried out within this phase, the original CASCADE program (or the English version thereof) served as a discussion tool. Initial findings (during the concept validation cycle) were presented to expert and (potential) user groups during the site visits. They offered feedback in the form of initial design ideas as well as tentative suggestions for future cooperative activities. These ideas pertain to the validity and the practicality of the (at that time, to-be-designed) system, especially in terms of which knowledge would be most relevant to include. As discussed earlier, validity refers to state-of-the-art knowledge and internal consistency; whereas practicality refers to instrumentality, congruence and cost, as presented below.

5.1.1 Validity

State-of-the-art knowledge [5]

Concept validation cycle results *(state-of-the-art knowledge: 1)*

Data collected during the first four circuits of activity pertaining to state-of-the-art knowledge related to the content of the system, as well as to the support and interface. Participant recommendations from circuits one (n=5) and four (n=5) regarding the to-be-built program included the idea that CASCADE-SEA should capitalize on certain strengths of the existing (original CASCADE) system; participants from all circuits also offered suggestions for new areas to address. They cited the 'structure for planning' as a major strength, saying that through this clear structure, the program helps the user think critically about the process. This was considered an asset in terms of the curriculum design and development knowledge in this system

[5] State-of-the-art knowledge refers to: curriculum design and development knowledge, related professional development knowledge; advice on materials design, guidance on embedding materials in professional development; and maximizing the potential of modern ICT facilities.

(content), as well as to the advice on materials design (support). Participants recommended various types of additions to the program. In terms of content, they recommended adding support for: textbook evaluation; test-making; designing alternative forms of learner assessment; creation of materials for programs, workshops and conferences; and consideration of peer coaching as a form of evaluation (or even analysis). Participants suggested that general support could be elaborated by offering more examples. Their ideas on supporting the creation of materials as part of user professional development included the following two issues: (1) focus user attention less on their own learning and more on getting the task (materials development) done; and (2) embed the development (and evaluation) of this tool in ongoing programs and activities. Finally, participants recommended two main alterations in terms of the interface (maximizing the potential of modern ICT facilities). Rather than having Word™ run multiple copies of itself when presenting more than one document to the user, they recommended opening the application only once, with additional documents opening inside it. Also, the suggestion was made to link a database with the instrument development inside the program so that analysis could be done with the same worksheets through which the instruments were created.

Site visit cycle results *(state-of-the-art knowledge: 2)*
Among other things, participants in this cycle were asked to articulate the kinds of knowledge (relating to content, support and interface) they thought would be most useful to offer through a computer supported curriculum development tool for southern Africa. With regard to the aspects of curriculum development that should be supported by CASCADE-SEA, the majority placed support for the process of design in the top priority. Although participants recognized that these two things often go together, support for the creation of teacher materials was considered more important than for learner materials. Participant opinions were mixed regarding whether or not CASCADE-SEA should provide subject-specific support (as opposed to only offering generic support) for making materials. But when the issue was explicitly addressed during the fifth circuit (SAARMSE), most participants said it should, frequently citing the reason that subject matter and teaching methodology are related; as one respondent put it, *"these two are like a hand and a glove."* Participants in this cycle recommended that the program support development of units (schemes of work; lesson series), and emphasize practical work and applications. Specifically aiding the user in articulating the link between teaching goals and (various forms of) learner assessment/monitoring was desired. A generic version was recommended for the whole region (as opposed to a one-country or site-specific version), and most participants felt that the program should somehow address learner-centered teaching. Also, individuals in each of the three cycles indicated that they saw applications for use of this type of tool in professional development programs.

Internal consistency [6]

Concept validation cycle results *(internal consistency: 3)*

During the analysis phase, comparatively little data were collected regarding internal consistency. In terms of program content, participants recommended that CASCADE-SEA explain how the decisions made in one part of the program have consequences for other parts of the program. Not only would this explain to the user how ideas in various components are in line with those in others, but it could also help them understand this concept with regard to the process in general (not just the process inside the program). Participants in this cycle emphasized the usefulness of the support offered through the document samples (instruments, tips, etc.) throughout the program.

Site visit cycle results *(internal consistency: 4)*

The issue of internal consistency was briefly addressed during the discussion in the fifth circuit (SAARMSE). Participants indicated that, once they became familiar with one area of the (original CASCADE) program, they also understood how to work in other areas. Further, they found the various forms of support, offered in a consistent fashion, easy to both locate and use. These benefits were seen worthy of keeping and even increasing in the next system.

Conclusions and implications regarding the validity (5)

The analysis phase was carried out to collect ideas regarding what, if any, type of system would be useful for supporting (science and mathematics education) curriculum development activities in southern Africa. The data collected during this phase, together with the simultaneous literature review, contributed to the following major insights in terms of CASCADE-SEA's validity; namely, the program should:

- Capitalize on strengths of the existing (original CASCADE) system, particularly in terms of offering a clear, consistent structure and exportable examples, samples and tools;
- Offer subject-specific as well as generic support for the process of designing lesson materials (particularly teacher materials);
- Be integrated (or integratable) in (science and mathematics education) professional development programs throughout the southern African region.

As is often the case when delving into most areas of study for the first time, the data collected during this phase led not only to answers, but also to additional questions. Even unanswered, the mere awareness of additional

[6] Internal consistency refers to: ideas in various components are in line with those in other areas; tips, guidelines, templates and advice are perpetually offered in a consistent fashion; functions as intended, regularly.

issues arising out of the data analysis was considered insightful. For that reason, two main questions that emerged as a result of this process are presented below:

- In order to make a tool that will include valid curriculum design and development knowledge that is useful to a wide audience, an understanding of the commonalties and differences within that audience is necessary. How should that information be gathered, and in what ways(s) should it be used to make program content decisions?
- State-of-the-art knowledge with regard to maximizing the potential of modern ICT facilities is likely to include integration of tools and functions that require an existing infrastructure in terms of computer facilities and the know-how to use them (computer literacy). Similarly, the state-of-the-art of curriculum development is not uniform across the globe. It varies depending on where it is taking place and who is doing it. To what extent should contextual factors influence the structure and content of the program?

Both of these questions pertain to the relationship between the quality aspects of validity and practicality. In order to consider them further, the analysis results pertaining to practicality are presented below.

5.1.2 Practicality

Instrumentality [7]

Concept validation cycle results *(instrumentality: 6)*

Data collected during the first four circuits of activity pertaining to instrumentality also included participant recommendations regarding the to-be-built program. Again, participants recommended that CASCADE-SEA should maintain and perhaps even elaborate certain strengths of the existing (original CASCADE) system. With regard to instrumentality, participants felt that CASCADE offers step-by-step guidance through the process of planning an evaluation. They valued the clarity and conciseness of both the procedure to be followed and the instructions on how to do so; and they encouraged more of the same. Finally, participants indicated that the buttons, navigation and functions were clear. No explicit changes relating to instrumentality were suggested, although one group did wonder out loud as to the possible merits of actually numbering all the screens in the program.

Site visit cycle results *(instrumentality: 7)*

With one exception, the site visits confirmed the previous findings related to instrumentality. That is, most participants found that CASCADE offers

[7] Instrumentality refers to: guides the user step-by-step in making materials, offers freedom to work at own pace and style; explains how to use program clearly and concisely; buttons, navigation and functions are clear.

clear, useful steps for planning an evaluation. They found it easy to get around the program and characterized the interface as user-friendly. Only during the sixth circuit, did one group (UB) experience difficulty. During the seminar, group discussion revealed that many participants appeared to be struggling to understand how one communicates with the computer (the roles of buttons, how navigation works, etc.). This might explain why they appeared to have difficulty grasping the concept of the computer as a support tool for complex tasks in general, and for curriculum development in particular. When the audience did eventually begin to understand (as evidenced by the questions asked during the group discussion), it was primarily staff that seemed to grasp the idea. For the students, this appeared to remain fascinating yet challenging to follow. This was the only circuit during the analysis phase in which preservice teachers (students) were involved. For those students with little or no background in formative evaluation (and/or computer use), the first-time introduction at the seminar was brief (the seminar was geared more toward staff than toward students). Those students who used CASCADE during the workshop had more time to become acquainted with the intent of the program and the content it addresses; still, for some, unfamiliarity with the computer was a hindrance. However, it was interesting to note that, despite the challenges presented by the lack of computer skills, participants appeared highly motivated to learn.

Congruence [8]

Concept validation cycle results *(congruence: 8)*

Three of the first four circuits of activity yielded data regarding congruence between the proposed system and the activities already undertaken by the target users. Participants indicated that, if a design component were added, a computer supported curriculum development tool would be especially useful and relevant; some suggested that this would be particularly valuable to teacher resource centers. They noted that such a tool could help facilitator teachers carry out their tasks of creating lesson materials together with other teachers from the region. Other participants recommended possibly creating two versions: one for teachers and one for professionals. The participants from Zimbabwe indicated that minimal facilities are available (usually one computer or less per center), and recommended that this be taken into consideration. The groups that were interested in being involved with the design and testing of the program also advised that decisions regarding the technology to be used be based on the facilities available in their centers.

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[8] Congruence refers to: linkage with the needs, wishes and context of the users; support is relevant and usable; interface 'feels' nice and safe, users are not alienated but motivated to use the program, operates on technology that is available in the target setting.

Site visit cycle results *(congruence: 9)*
During the remaining three circuits in the analysis phase, additional data related to congruence were collected. In terms of linking up with the needs, wishes and context of the users, a few participants (primarily the students involved in circuit six - UB) found a direct link between CASCADE and their own activities difficult to establish. Most of these participants were new to the field of curriculum development and to computers, but they appeared highly motivated. Although little more than half of the participants in circuit five (SAARMSE) indicated that they had ever used the 'analysis, design, evaluation' approach to curriculum development before, they all indicated that this seemed to them to be a realistic and useful approach. The majority stated that CASCADE fits (often intuitively) with the way that they do their (formative evaluation) work. When asked what tasks the participants do related to curriculum development (toward understanding those potentially supportable by a computer-based tool), most of them indicated: creating exemplary materials (in particular, lesson plans). Some also included the development of tutorials, exams, inservice materials or textbooks.

Two of these groups (from circuits five and seven) offered suggestions on how to enrich congruence of the to-be-designed program. In terms of content, they recommended that CASCADE-SEA help users to identify problematic areas (subject matter) and areas in which materials are lacking (in schools) so that those developed with CASCADE-SEA are truly useful (by filling an existing void). Further, participants indicated that CASCADE-SEA should encourage and demonstrate the use of local resources as much as possible. A frequent caveat was that the program should be structured for flexible use. In terms of the support offered, participants recommended the addition of tutorials as well as reminders to the users to address local beliefs, knowledge and existing 'village technology' in lesson materials. Finally, with regard to the computer technology available in the target setting, most users (for example, eight out of ten in circuit five) indicated that they work in a Windows environment (with a mixture of Windows 3.11 and Windows 95 operating systems). Very few users had access to email or Internet at the time. With the exception of the students in circuit six, most other participants indicated that they felt comfortable working with computer programs, and that they use a computer at least three days a week. The majority used Microsoft Word for word processing, but were unable (or chose not) to describe the processor speed on the machines they use most frequently.

Cost [9]

Concept validation cycle results *(cost: 10)*

During the concept validation cycle, participant feedback rarely related to the issue of cost. One group (NL1) did mention that they felt the interface could be improved in this regard if it were to draw more attention to the 'announcements' area (this part of the screen contains instructions for the user). The lack of data in this area may well have been related to the approaches used during these circuits: mostly walkthroughs and demonstrations. Relatively brief, non-naturalistic exposure to a new set of ideas (CASCADE) was not likely to have been the most conducive format for learning about the ratio between the amount of return and the amount of investment. It was understood that participants would require time and the opportunity to get to know the program a bit better before they could offer much comment in this regard.

Site visit cycle results *(cost: 11)*

During the remainder of the analysis phase, additional cost-related data were collected during the fifth circuit (SAARMSE). Participants were satisfied with the content of the program (formative evaluation), and felt that it contained sufficient support. All (n=24) except one participant in this circuit described the program as useful; and all but one described their experience with the system as non-problematic. Further, all participants in the fifth circuit said that they found the program to be realistically timed. That is, they were able to plan their evaluations within the time allotted during the workshop.

Conclusions and implications regarding the practicality (12)

As previously mentioned, the analysis phase was carried out to determine what, if any, type of system would be useful for the target setting. Primarily, this meant identifying design ideas for the validity of the program (e.g. what state-of-the-art knowledge should be included). But as noted in the conclusions and implications regarding the validity, these decisions are not totally unrelated to practicality issues. The data collected during this phase, together with the simultaneous literature review, contributed to the following major insights in terms of CASCADE-SEA's practicality; namely, the program should:

- Capitalize on and perhaps elaborate the advantages of the existing CASCADE program, with particular regard to the step-by-step guidance which increases instrumentality and lowers the cost threshold.

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[9] Cost refers to: content should include enough of what the users need and not bog them down with unnecessary steps; support should be extensive, lowering the threshold of investment cost to the user; interface should reflect the flexibility of the system, in which users determine how they would like to go through the program (maximum degree of freedom, minimum allowance for error).

- Specifically target facilitator teachers working in resource centers (often sharing computers), and the creation of exemplary lesson materials. Any considerations of potential applications for preservice education should be given low priority at this juncture.
- Operate within (at least) a Windows environment, and assume only basic computer literacy among its users.

5.2 Design: On the right track?

Through iterative cycles of design, development and prototype evaluation, the CASCADE-SEA tool (described in Chapter 4) evolved. This evolution took place through four main cycles. During the first cycle, prototype one was evaluated through four activity circuits, with participants from the Netherlands as well as three universities in the USA. The Lesson Builder (prototype two) underwent three separate evaluations, which took place in the Netherlands, Zimbabwe and Tanzania. The third prototype cycle was composed of ten activity circuits with participants from the Netherlands, Swaziland, South Africa, Zimbabwe, Tanzania and Namibia. The last prototype was evaluated during six circuits, with activities in the Netherlands, Namibia, South Africa and Zimbabwe. During this phase, developer screening, expert appraisals, micro-evaluations and tryouts were conducted. Findings from earlier prototype evaluation cycles were integrated into subsequent prototypes. In addition to exploring the validity and practicality of the prototypes, latter circuits also began to study the impact potential (whether or not use of this system yields better quality materials and/or enhances the professional development of its users). The results of the formative evaluation activities are presented in this section.

5.2.1 Validity

State-of-the-art knowledge

Prototype 1 cycle results *(state-of-the-art knowledge: 13)*

Data pertaining to curriculum design and development knowledge collected during formative evaluation of the first prototype related to the four main areas in the program, as well as to the program as a whole. Although noone challenged the value of its existence, expert opinions were mixed in terms of exactly what the rationale component should address and how it should be organized. Some felt that this area of the program should "address learner, society and subject matter;" others said that the rationale should be split into three areas - constructivism, cognitivism, behaviorism - then subdivided accordingly; and still others offered suggestions on how to improve, while not severely altering, the existing structure. Various participants in this cycle emphasized the importance of considering the desired roles of both teacher and learner in the classroom. One participant pointed out that the basic beliefs addressed in the rationale component influence more than the design orientation that was shown in the early rationale: *"For example, the approach toward teaching and learning (such as student-centered learning) is something that influences all products."*

Few recommendations pertaining to the content of the analysis portion of the program were offered at this stage, although the idea of possibly excluding it was brought up, as well as the possibility of merging the design and analysis components. In contrast, many ideas were offered for the design portion of the program. Experts felt that when it comes to setting goals, any taxonomy used should relate to what the teachers (in the target setting) already know. They recommended further investigation into what paradigms teachers already use, and some participants offered up their own preferences, the most common of which examines knowledge, skills and attitudes. Further, numerous suggestions were given on how to elaborate the existing structure in the design component. For example, participant recommendations included potential options to be given for choice menus (e.g. cleanup options could include: wash things off; leave in place; take home); ideas for main areas in a lesson plan template (introduction, body, activity, conclusion); and recommendations on how to help users structure the content of a lesson series (concept mapping and heuristics like working from known to unknown concepts; small to large; chronological; etc.). Finally, regarding the evaluation component, participants recommended re-working the main evaluation questions and simplifying some of the options (for example, eliminating the articulation of respondent roles in the formative evaluation).

In overall comments regarding the content of the program, participants suggested that CASCADE-SEA target the design of (primarily) innovative lesson materials; they also noted that innovations can only, realistically, be approached when the teachers are comfortable with the subject matter. Further, the recommendation was given that the program support only the creation of teacher materials, and offer heuristics and tips for coordinating learner materials (as opposed to trying to support development of both, simultaneously). Lastly, many recommendations were provided in terms of (mostly theory-oriented) literature that should be consulted for further development of various aspects of the program.

Participants also offered suggestions regarding advice on materials design (support) provided through the program. They stressed the importance of encouraging users to articulate why certain decisions are being made (e.g. Why certain teaching methods? Why this particular subject matter? Why does this material need to be developed?). They also indicated the significance of having a clear "what do you want, exactly" answer upon completion of the rationale phase. Participants recommended the use of metaphors. Some recommended metaphors in terms of the program as a whole and others in terms of helping the user make particular decisions in certain areas within the program. Similarly, the idea of creating an agent (a character expressing the voice of CASCADE-SEA) was raised. Many participants emphasized the importance of offering a wide range of examples and heuristics throughout the program, and offered some guidelines on how to go about this. Offering additional sources of information (literature) and lists of commonly referred-to issues (such as learner misconceptions) are examples of some of the guidelines provided by participants. During this cycle, experts recommended that CASCADE-SEA offer generic (not subject-specific) support. Other comments relating to the forms of support offered included ideas specific to certain areas (that might be applicable to others) like, *"Provide a long list of analysis questions, and the opportunity for the user to decide which ones are most appropriate."* Finally, one participant pointed out that merely asking a question can trigger reflection (on behalf of the user), regardless of whether or not the answer to that question is linked to other parts of the program. For this reason, the expert said, *"Don't feel you can only include questions [in the program] that CASCADE-SEA can specifically use."*

In terms of the technical and interface-related data emerging from this cycle, a number of participants raised the question of re-designing the entire program to be an 'ask' or 'expert' system (so that the program would evaluate and analyze user input, producing ready-made solutions on the spot). Less drastic ideas in this regard included the use of such facilities within parts of the program, like a 'Windows Troubleshooter' or configuration wizard that puts (parts of) the system on a sort of automatic pilot when the user so desires. At the very least, it was recommended that users be offered an "I don't know" option, which tells the computer to provide additional support. At the same time, this would force users to recognize points for further consideration on their part. Finally, links to outside programs (concept mapping, graphic calculator, database, etc.) were also recommended; in some cases, ideas were given as to which ones and why.

Prototype 2 cycle results *(state-of-the-art knowledge: 14)*
Because the second prototype (the Lesson Builder) specifically supported the design component, data collected during this phase also focused on this area. Participants were satisfied with the general structure and content of this prototype, and focused their recommendations on elaborating specific aspects in the program. For example, they recommended: adding more sub-topics; reminding the materials designer to connect to learners' prior knowledge; and adding a section for teacher notes. In terms of the support offered, participants indicated that this program can be very useful and helpful to teachers in simplifying lesson preparation. They found it easy to use but did offer a few recommendations for improvement. Minor suggestions related to individual areas inside the program (e.g. participants recommended elaborating the timing options). One main concern was raised pertaining to the system as a whole. The words of one participant

summarize the concerns also noted by others, *"like any model, its basic assumption could limit teacher creativity."*

Regarding the use of state-of-the-art technical possibilities, participants appreciated the idea that CASCADE-SEA provides a virtual library. Various teachers in circuits 13 and 14 commented on the ease with which users could save (and later access) plans made by themselves or others; they liked the fact that existing materials could be shared, polished or improved upon; and one even noted that this program is *"easier for reference than books."* Participants (especially from circuit 13) also recommended some extensions in terms of functionality: the addition of a button that automatically adds words (along with definitions) to the lesson plan; applying the database principle to other areas of the program (like the vocabulary page); being able to click on words in certain places and have them be copied automatically into the appropriate fields (such as in the objectives area).

Prototype 3 cycle results *(state-of-the-art knowledge: 15)*

With regard to the third prototype, participants again appreciated the structure and content of the program. For example, in circuit 19, facilitator teachers were asked to indicate their opinions regarding whether or not the CASCADE-SEA program is logically organized. On a scale of one to six (one = illogical, six = logical) the mean response (n=13) was 5.15. Participants involved in this cycle did, however, offer some concerns and recommendations for improvement. Concerns included the fact that the CASCADE-SEA program content is not A-level (Advanced, in the Cambridge system) based (this was explicitly mentioned by only one participant, but indirectly came up through other sources as well). Another concern raised was whether or not all users of the system would feel comfortable sharing their materials via the program. All participants (n=12) in circuit 16 indicated willingness to contribute their own lesson plans and activity ideas to CASCADE-SEA's databases, both on the Internet and on the CD-ROM. Student teachers involved in circuit 21 recommended the addition of sections on motivational techniques and assumed/prior knowledge in the lesson builder. Participants from South Africa made specific suggestions for tailoring the program toward OBE (please refer to Van der Laan, 2000, for details). Recommendations regarding support included more frequent reminders (such as the need to set standards when writing objectives for mathematics or what a reasonable amount of objectives would be for the allocated lesson time); and additional ideas for helping users consider how to make decisions regarding lesson content (for example, by asking if the content is familiar but not too difficult; familiar but difficult; new but not too difficult; new and difficult - and basing recommendations accordingly). Finally, participants were very positive about the linked (external) programs, especially Mindman©. A few (minor) technical improvements were suggested, such as adding the possibility to make lists in the text boxes (more than one line).

Prototype 4 cycle results *(state-of-the-art knowledge: 16)*
The last cycle during the design phase collected comparatively little data in this area from external participants. However, the developer screening did examine the state-of-the-art knowledge embedded in the program's content, support and interface. Because the analysis component was elaborated for the first time in this prototype, this area received the most attention during the developer screening. Recommendations for improvement included explanation of the idea that priorities (in the design guidelines area) should be based on gaps between the three types of results (issues synthesis, perception poll and classroom profile). Also, it was noted that the analysis component should not only emphasize observations of the current situation, but also idea generating: addressing good quality interventions/innovations with regard to the materials to be developed. Specific suggestions were generated for improving the options offered in the checklist, design guidelines and instrument (especially observation) areas. It was noted that some of the instruments offered in the analysis component could do better in terms of encouraging the user to think, particularly by adding more 'why' questions and not just asking 'what' questions. Lastly, all three circuits collected ideas for improving the functionality. Relatively speaking, these were minor (e.g. CASCADE-SEA documents should be associated in the Windows registry).

Internal consistency
Prototype 1 cycle results *(internal consistency: 17)*
In terms of how the ideas in various components of the CASCADE-SEA program are in line with those in other areas, data from this cycle yielded recommendations that were mostly geared toward links *within* individual components (as opposed to *between* program components). Pertaining to the design component, participant suggestions were mainly of two types: general and specific. General recommendations pointed out links that should exist but did not include ideas on how to do it, like this: *"the content area affects sequencing," or "objectives and assessment should be linked."* Specific recommendations included how to manifest certain ideas, such as: *"The introduction (of the lesson) should include a link back to the previous lesson. Have the user complete the following sentence 'Remember that yesterday we were talking about...'"* Some recommendations were also given regarding consistency between components. Mainly, these had to do with connections between the rationale and one other area (at a time). Participants recommended that the user be encouraged to return to the rationale area after completing an evaluation. They also suggested that at the end of the design phase, users should be reminded of the choices that they made regarding implementation of their materials. Additionally, other choices made in the rationale area should be fed back to the user during design.

Data collected during this cycle also contributed to ensuring that support be offered in a perpetually consistent fashion. Participants emphasized the importance of key word repetition (being sure to use the same terminology to describe certain things throughout the program). They also found the creation of templates to be useful and recommended that each main component contain a document that summarizes user decisions in editable form (like the evaluation plan). In fact, consideration of varying templates based on different styles (behaviorist, cognitivist, constructivist) was even suggested. During circuit 11, experts suggested that too many examples might be overwhelming, saying *"if you include a wizard, you don't need examples."*

Experts involved in this cycle also contributed insights regarding the internal consistency of the interface and technical aspects of CASCADE-SEA. For example, they recommended that all navigation areas be the same, and they should use (as much as possible) icons that are already familiar to computer literates (such as left and right arrows for moving forward and backward). They recommended disabling options that were illogical or impossible, and suggested that dimming inactive options would be superior to hiding them as it indicates to users that this could be (but is not now) available to them. Further, addition of standard Windows functions (cut, copy, paste) and safety features (original documents should be locked or read-only to prevent accidental overwriting) were advocated. Some small technical glitches were also identified (a few indicator dots and suggestion checkmarks were missing).

Prototype 2 cycle results *(internal consistency: 18)*
Few new ideas were generated with regard to the internal consistency of the program during the formative evaluation of the second prototype. This may be due to the fact that the second prototype featured only one component (design). Participants from Zimbabwe (circuit 13) mainly emphasized that the database idea was "nice," and should be elaborated to include more examples (applicable to more areas in the program than just the lesson body). The group from Tanzania (circuit 14) helped to identify places where the program did not function as intended. They found that some of the text-entry fields were too limiting; and observation showed that remembering to press the 'Enter' key (for the computer to accept the text entered) was too much of a burden. During this cycle, teachers did indicate that the program screens (layout) were consistent. Finally, they suggested that an improved search filter would be useful, saying *"as it is now, the computer sometimes brings forth information which is not necessary."*

Prototype 3 cycle results *(internal consistency: 19)*
The third prototype re-integrated rationale, design and evaluation components. Participants recommended that the link between rationale and design be stronger, although very few suggestions were given as to how

to achieve this. The most concrete advice was to include reminders like, "have you built learner-centered lessons?" And a few suggestions were given by counter-example: *"The program allows you to start writing materials, even when you have indicated that you are not yet sure about what topic you will address."* One participant (a teacher from Zimbabwe in circuit 19) noted that the consequences in some phases of the program are stronger than in others, citing the evaluation component as an example of where one's actions have clear consequences. Another issue that was raised concerned the relationship between rationale and analysis, specifically (as pointed out during the developer screening) *"some of the questions asked in the rationale are actually analysis questions."* In terms of ensuring that the program functions as intended, regularly, data loss was a problem and a source of frustration during this cycle (few safeguards had been built into this prototype). Workshop participants indicated that saving options should be improved (circuits 19, 20, 21, 23). For example, all ten of the student users involved in circuit 21 lost (some) data at least once.

Prototype 4 cycle results *(internal consistency: 20)*

Compared to previous prototypes, recommendations (from external sources) pertaining to the internal consistency of the CASCADE-SEA program were minimal. During circuit 28 (SEITT's residential training period), participants did suggest that the tools offered (in the toolbox) should correspond to the topic selected in the rationale. The remainder of suggestions in this area evolved from the developer screening. It was recommended that additional explanation be offered to the user, to facilitate the comparison/contrast between the results from various strategies. If offered in the guidelines area of the analysis component, this would help to point out gaps between desired and existing situations. Similarly, additional explanation would be useful toward helping the user understand consequences of actions taken in the analysis phase (specifically related to the checkboxes in the questions and strategies pages). It was noted that some pages (mistakenly) used different terms for the same thing; and in some cases, alternative terminology was discussed (e.g.: changing all references about 'issues synthesis' to 'policy synthesis'). Two inconsistencies in the support were identified for improvement: (1) the user selects the number of respondents (in analysis) before being offered the information on how many respondents to select - this does not make sense; (2) the approaches in the analysis component might appear intimidating, and thereby contradict the (rapid) prototyping approach which is advocated through CASCADE-SEA.

Conclusions and implications regarding the validity (21)

During the evolution of the various prototypes, formative evaluation data informed development of the program as well as elaboration of ideas on what the program should actually aim to do. For example, determining exactly what the rationale component should address (state-of-the-art knowledge) and how it should be tied into the ideas in other areas of the program (internal consistency) was a topic that evolved throughout the design and development phase. The rationale started out (in the first prototype) as mostly an organizational area addressing primarily general information about a materials development project, and grew to be (visually and operatively) the hub of the program in the fourth prototype. Further, earlier notions about possibly making CASCADE-SEA into an 'expert' system were eventually discarded in lieu of developing a program that, in addition to supporting the complex task of curriculum development, also strives to contribute to its user's professional development. For example, the decision was made to endeavor to make the process of curriculum development transparent and even inviting. This meant that being able to generate materials quickly and easily was not an exclusive priority. Explaining (to interested users) why certain processes are recommended and how they might be carried out also became important. Facilitating user learning about the complex process of curriculum development was supported by the fact that decisions in one area of the program influenced other areas of the program.

As previously mentioned, the acquisition of new insights frequently leads to the acquisition of new questions. With regard to maximizing the potential of state-of-the-art ICT, a number of opportunities existed; yet deciding how to take advantage of them (if at all) was linked to practical matters. For example, initial concern was expressed as to whether or not users would feel comfortable sharing their work. Latter evaluations showed that participants greatly appreciated the opportunity to share with fellow colleageus, even asynchronously. This insight led to the question of whether or not (and to what extent) CASCADE-SEA should be available via the Internet. And, in turn, this led to further questions such as: Should additional resources be incorporated to facilitate sharing through this medium? How about information pertaining to those individuals who contribute, so that teachers may contact them if they desire additional information? Questions such as these demonstrate just how connected the aspects of validity and practicality can be. The following section examines other issues that may have started out as 'what to address' questions and eventually evolved into 'how to do that' discussions.

5.2.2 Practicality

Instrumentality

Prototype 1 cycle results *(instrumentality: 22)*

Data collected during the first four circuits related to CASCADE-SEA's ability to guide the user step-by-step in making materials pertained primarily to the sequencing of program content. Even though the first prototype of CASCADE-SEA did not force the user to walk through the program in any specific order, the visual presentation did suggest a particular path. Experts participating in circuits nine and ten contributed suggestions to improve the sequencing (and in some cases, the clustering) of the content. For example, they recommended separating the aims (of the materials, in terms of offering support to the teachers), the goals (of the lesson series, in terms of learner outcomes) and the lesson objectives. In addition to suggesting changes related to the sequence of tasks, recommendations were also made to optimize placement of explanations and advice in the program. One particular type of guidance was explicitly addressed: that which encourages the user to work at one's own pace and style. Toward this end, participants recommended adding "I don't know" options to many parts of the program along with outright encouragement to look to other sources outside of CASCADE-SEA, (including one's own good ideas) for ways to go about materials development.

Suggestions were also given toward improving the clarity and conciseness with which instructions are offered inside the program. This related mostly to the wording on certain pages, but also included (ironically) recommendations for additional explanations. Participants in three out of the four circuits during this cycle explicitly suggested that CASCADE-SEA should (somewhere in the program) tell the user about the ideas upon which this software is based: a list of 'golden principles.' Not surprisingly (as discussed in this section on validity) recommendations were even given as to what those principles should be (e.g. the program aims to offer immediate support, to assist in sharing, etc.). The addition of more examples was also seen as a way to improve explanations. Related to this, participants in circuit 11 offered suggestions regarding program-wide metaphors that could be used (e.g. comparing the curriculum development process to cooking, gardening, or taking an expedition). Finally, participants recommended teaching the user how to access various forms of help, right from the start of the program.

In most cases, the program screens spoke for themselves. This implies that the interface (buttons, navigation and functions) were clear, although room for improvement certainly existed. In particular, the navigation panel was weak. Its placement was seen to be 'unnatural' in the upper right portion of the screen, and the navigation options were too limited. Also, some participants felt that too much text was located at the top of the page. The suggestion was made to divide the kinds of instructions being given such that procedural information be offered at the top of the page and content-related information be offered in the page body. Here too, suggestions were made in terms of the wording (button labels could be clearer). Lastly, roll-over (additional text explanation) functions were appreciated; participants recommended more of the same throughout the program.

Prototype 2 cycle results *(instrumentality: 23)*
Comparatively few new insights in this area were obtained during the formative evaluation of prototype two. However, teachers involved in the hands-on session in Tanzania (circuit 14) said that they found the program easy to work with (clear). At the same time, they offered recommendations for improvement, which included ways to elaborate some of the existing, recommended steps as well as alternative terminology for some program functions.

Prototype 3 cycle results *(instrumentality: 24)*
Participants involved in cycle three indicated that they were satisfied with the step-by-step guidance offered by CASCADE-SEA in making materials. Some individuals explicitly mentioned that the curriculum development process, as presented by CASCADE-SEA, is more structured than what they were used to. All three types of users (experts, inservice teachers and preservice teachers) indicated that they felt CASCADE-SEA makes the creation of materials easier; many said it also saved them time. Participants from various circuits further commented that the structure offered via the program makes it quite conducive to being a useful learning tool (see Box 5.1). For example, experts in circuit 17 recommended that CASCADE-SEA would be useful in graduate programs in curriculum development, for both master's and doctorate level. Some concern was expressed (by participants in circuit 19) at the possibility that the program might in fact offer too much guidance, causing the users to "become lazy."

> "This package really makes you sit down and think about what you're going to teach, how you're going to teach, how much time is spent on certain activities, what materials are necessary, how it can be that improved, etc. …A moderator of a TRC can indeed use this program for teacher training and development."
> *- Expert (circuit 16)*

Box 5.1: Expert citation

Most participants appreciated the freedom offered by CASCADE-SEA in terms of being able to work at one's own pace and style. For example, student participants in circuit 21 expressed satisfaction with the way CASCADE-SEA generates a draft and then allows the user to edit that. Senior participants in this circuit, however, were less happy with the flexibility offered in the program. The preservice lecturers felt that the students should follow certain prescribed steps in working with the program and not be allowed to start "just anywhere." In this respect, they felt that CASCADE-SEA offers too much freedom, and they would prefer tool that be clearly more linear in nature.

The majority of participants in this cycle indicated that they found the program easy to use, and the support and interface to be clear. One way in which this aspect was measured was by asking participants to rank the clarity of the information (one = unclear, six = clear) on certain screens while (or immediately after) working with the program. During circuit 19, the mean response (n=13) to this question in reference to the rationale profile screen was 5.1. Likewise, few participants in circuits 20 said they ever got lost in the program and five out of seven participants in circuit 22 judged the interface to be clear. Similar data from comparable sources in these and other circuits confirmed the general impression that support, navigation, buttons etc. were mostly (though rarely completely) clear to users. However, observation and discussion data showed additional room for improvement in this area. Participant comments and questions both during and after hands-on sessions indicated that clarification had yet to be optimized with regard to the following main areas (in order of frequency):

- English language terminology (this was the most frequent comment: the phrasing was a challenge for many English-as-second-language users);
- Organizing series content (clustering and sequencing was new to many users);
- How to input media and materials (the third prototype did this automatically and did not allow editing, a feature that confused many users); and
- Navigation arrows (some participants were not familiar with the idea of left and right triangular arrows to indicate forward and backward movement);
- Editing in a word processor (many participants were new to computers).

Prototype 4 cycle results *(instrumentality: 25)*
Compared to the previous cycle, few new insights were obtained during the formative evaluation of prototype four, concerning instrumentality. Previous findings regarding user freedom and the clarity in the program were confirmed. For example, five out of six participants in circuit 27 agreed (two strongly agreed) with the statement, "the CASCADE-SEA program encourages user input." And eight out of nine participants in circuit 30 indicated that the structure of the CASCADE-SEA program was clear (three said very clear) to them. In terms of step-by-step guidance offered by the program, participants in this cycle recommended additional explanation be given for the research phases (analysis and evaluation). They asked for more tools and guidelines for reporting (this request came primarily from those involved in circuit 28; these SEITT teachers were involved in classroom research as part of their facilitator training).

Additionally, two circuits in this cycle explicitly addressed the question of how often (if ever) participants would use CASCADE-SEA if it were available in their region. Of the 47 teachers asked, 21 answered, "once a week or more"; 18 answered, "once every few weeks"; five answered "once every few months; zero answered "once a year (or less)" but three did not respond to the question. New computer users did struggle at the beginning of most circuits; but participants taught each other and many learned quickly. Still, participants in circuit 26 did recommend improvements in the left navigation panel. The remainder of improvement suggestions were generated during the developer screening. Most of the comments made during this circuit (pertaining to instrumentality) were directed toward improvement of the analysis component. Polishing guidance (in the analysis component) to help the user focus on a few aspects in detail (rather than many things, superficially) was a common theme throughout the data in this circuit.

Congruence

Prototype 1 cycle results *(congruence: 26)*

Given the fact that prototype one was evaluated by experts in the Netherlands and the USA, it is little surprise that few data relating to how the program links up with the needs, wishes and context of the target users were collected during this cycle. Experts did suggest the importance of: looking into ways to improvise when resources are scarce; how the concept of sharing one's work relates to the target setting/culture; and making sure that the CASCADE-SEA program outputs match the political agenda on a school, regional and/or national level (this relates to needs and context analysis as well as to other areas in the program).

In terms of support being relevant and usable, participants in this cycle suggested that the facility options (time, money, etc.) be replaced with default values, or at least that this representation of 'layers of necessity' be de-emphasized. Experts (circuit 11) suggested that the target users are probably not accustomed to thinking in terms of goals/objectives, so CASCADE-SEA should build up slowly to this concept. Participants in circuit nine recommended including pre-made objectives in the text entry areas, derived from a synthesis of relevant syllabi from Cambridge, South Africa and Zimbabwe. Participants also stressed the notion that materials design might, in reality, be carried out more by teams then by individuals. Finally, a number of questions were raised with regard to the relevance of the support: Does CASCADE-SEA reflect a contextualized way of design? Is the procedure for designing materials different for an oral culture? What is the world-view of those people who will use this system?

Formative evaluation data collected during this cycle also yielded insights with regard to the interface, how it feels, whether or not it is motivating, and if it operates on technology that is available in the target setting. Some of the terminology was considered to be 'too jargony,' while (less) other terms were judged to be 'too traditional.' Participants expressed concern that users might consequently be alienated; and specific improvements were also recommended in this regard. Other potential threats to user motivation were screen clutter (especially in the evaluation area - the most elaborate portion of this prototype); and along with that, a challenging interface for new mouse-users (buttons etc. could be difficult for novices to operate). It was recommended that using more colors and icons might help lighten the overall tone of the program, as would an interactive agent. However, participants cautioned that the selection be made carefully because colors, symbols and metaphors have different meanings to different cultures.

Prototype 2 cycle results *(congruence: 27)*
In terms of speaking to the needs, wishes and context of the users, the 'idea book' was received with much enthusiasm; teachers said they would like to see that elaborated. Similarly, they felt that the clip art gallery was quite promising, but this too needed more content. Further, participants from circuit 14 recommended adding content knowledge that teachers might not have as well as local illustrations and visual aid ideas. Participants felt that the program facilitates the work of designing and writing lesson plans in a quick and desirable way, and they offered a number of comments with regard to the technology that is available in the target setting. They noted that new initiatives were on the horizon, which would target teacher resource centers for distance education and include Internet connections. They asked about how materials developed with CASCADE-SEA could be integrated with PageMaker (the desktop publishing program preferred by the TEAMS project). Finally, participants indicated that they felt CASCADE-SEA required few materials since *"preparing lessons can be centrally located where teachers can go and make use of the program."*

Naturally, practical concerns were also voiced. In terms of reproducing materials, participants pointed out that funding for schools to buy plain paper and other printing supplies is lacking. They noted that this can only be useful to schools that have electricity, and therefore would not be beneficial to rural areas. Due to the limited access to computers as well as moderate computer know-how and the expenses associated with training people, using the program requires either existing infrastructure or a significant investment. Further, because the program runs on Windows 95, powerful hardware is necessary. Finally, two participants felt that that one needs to be fairly comfortable with the computer to make use of the program.

Prototype 3 cycle results *(congruence: 28)*
The formative evaluation activities carried out with the third prototype afforded numerous opportunities to study how the system does (or does not) connect with the needs, wishes and context of the users. In general, participants indicated that they felt the program did. This was evidenced through answers to direct questions on this topic (e.g. all teachers involved in circuit 22 indicated that they thought the program "fits with their current practice"). In addition, participants (TIE officials in circuit 20) requested that the program be installed on their local computers. Finally, concrete suggestions were made for how the program could be integrated into teacher education programs in Zimbabwe (circuit 21).

But a number caveats were still raised related to congruence. The CASCADE-SEA program had been designed for facilitator teachers in science and mathematics looking to create exemplary lesson materials with fellow teachers. Nevertheless, in line with the cooperative, evolutionary nature of this study's design, participants eager to explore applications in other settings/circumstances were encouraged to do so. Consequently, the third prototype of CASCADE-SEA was used by preservice teachers, (regular) inservice teachers, facilitator teachers and even professional curriculum developers. From each group, some participants were specialized in science and/or mathematics, but some were not.

Although opinions were mixed as to why, it became clear that this program was not *equally* suitable to all (types of) groups. Participants clearly (but not unanimously) indicated that this program was well-suited to the needs of facilitator teachers. The curriculum developers echoed this sentiment with regard to their own needs. Those involved with preservice education (namely, lecturers and preservice teachers) agreed that this would be useful to the teacher training colleges. The students generally pointed out the time-saving aspect as the program's greatest asset. The lecturers (all of whom had at least five years teaching experience and lectured in the area of applied education) generally listed the addition of a new resource (and related approach) as the greatest advantage. This was true for four out of the five lecturers in circuit 21; the fifth was negative about the introduction of a new approach (see Box 5.2, left). As for applications for non-facilitator teachers, the consensus was that this program offers more than would interest them and requires too much effort for daily planning. For example, participants found formative evaluation to be "unnecessary for regular teachers." Experts identified that the program was not targeted to the average teacher: *"Inexperienced teachers or uninformed teachers need content and method guidance; this package is designed for schools with fairly experienced teachers,"* (circuit 22). And teachers generally felt the same way. Said one (non-resource) teacher, *"I would be able to use it [CASCADE-SEA], but I would not choose to use it, because it is not suited to individual teachers - but rather to key teachers,"* (circuit 23).

> "The CASCADE-SEA approach is too American. It uses the investigative approach to learning, which students in Zimbabwe are likely to find difficult as they are used to a prescriptive approach, where the lecturer literally prescribes to students how to prepare lessons following a certain format. It is this format that the students are used to during their teaching practice."
> - *Lecturer (circuit 21)*

Box 5.2: Lecturer citation

Although done so from the varying perspectives of different user groups, improvements were also recommended during this cycle. When asked to rank the usefulness of CASCADE-SEA in preparing lessons for Curriculum 2005 on a scale of one to five (1 = very useful; 5 = useless), the mean response was 2.14 with a standard deviation of .93 among the 28 participants (circuit 23). Nonetheless, South African participants (some, more than others) wanted OBE-based processes to be emphasized more clearly in the program. Participants from circuit 23 offered concrete suggestions on how to go about doing this.

Those facilitator teachers involved in hands-on sessions recommended including additional subject-matter support. The issue of computer literacy was also raised. While some participants saw familiarity with the computer to be a pre-requisite to being able to use the program, others saw the use of CASCADE-SEA as good way to introduce teachers to the benefits of using the computer. In either case, user motivation (to work with the computer) was nearly always remarkably high. Despite myriad frustrations (ranging from power failures/lost work to not being able to type well), most participants involved in this cycle remained eager (many of them gave up weekend or vacation time to attend the voluntary workshops). Finally, additional improvements related to language use, bugs in program functionality, and typing errors on the screens were generated. (These suggestions are summarized in the data summaries in Appendix H. For complete listings, please refer to Kafanabo, 1999; Madzima, 1999; Nijhof & Wagenaar, 1999; Van de Put, 1999; and Van der Laan 2000.)

Prototype 4 cycle results *(congruence: 29)*
Data collected during formative evaluation of prototype four with regard to congruence confirmed (many of) the findings from the previous cycle. Here too, participants felt that CASCADE-SEA links with the needs, wishes and context of its users. For example, 87% of the participants (n=54) in circuit 29 thought that the program was "applicable" for their context (teacher educators were assessing CASCADE-SEA as a teaching tool for their students). Resource teachers during this circuit looked at the program as a tool they would use to create lesson plans, together with teachers in their centers. Additionally, all participants in circuit 30 indicated that they felt CASCADE-SEA was "relevant" for the development of their (OBE) lesson plans (seven out of nine said "very relevant").

Computer-related concerns were also raised. In evaluating hands-on experiences, participants were sometimes frustrated with the short amount of time they were allotted due to the need to share machines. While most participants were quite positive about the use of CASCADE-SEA in the facilitator training program (circuit 28), one emphasized that the transfer of new knowledge and understanding would be minimal if CASCADE-SEA were not *"taken to SMCs [science and mathematics centers] while ideas on it are still fresh."* In terms of increasing motivation to use the computer, some respondents (circuit 29) felt that the use of CASCADE-SEA had increased computer awareness among lecturers and students at teacher training colleges.

New ideas regarding the congruence of CASCADE-SEA generated during this cycle pertained primarily to expanding its functionality, so that it might be usable for other grade levels and topic areas. All three of the non-science educators involved in circuit 27 indicated that they felt the CASCADE-SEA approach was useful for lesson development in their own subject areas. Said one, *"I lecture in philosophy and history and believe it can be adapted to develop lectures in philosophy and history for teacher trainees."* Similarly, participants in circuit 29 recommended specific changes in the program, which would render it (more) useful for primary school lesson preparation.

Cost

Prototype 1 cycle results *(cost: 30)*

From the first prototype, CASCADE-SEA aimed to offer enough of what the users need without bogging them down with unnecessary steps. In this regard, two main issues were raised during the formative evaluations of prototype one. First, this prototype asked the user for input regarding facilities available, with the intention of being able to base recommendations on this information. While the experts involved in this cycle understood the intention and the relevance of this approach, they expressed concern that user enthusiasm might be sapped when (as would often be the case) users would have to indicate that they have few facilities available. While some recommended removing this aspect of the program, others suggested variations on the theme of presenting a range of options to the user (not just one option, based on the facilities information). For example, suggestions could be ranked like "must do…, should do…, maybe do…"; others recommended assuming that few facilities would be available and simply offering "if you have got additional... then..." types of options. Another issue raised during this cycle about the concern of over-burdening users with unnecessary steps, relates to needs and context analysis. Experts recommended suggesting the importance of formal analysis only to those who are working on large-scale projects, and said that small-scale projects can, should and would jump right into design without conducting analysis activities.

Questions related to costs not only addressed 'how much is too much' in terms of content, but also 'how little is too little' in terms of support. CASCADE-SEA aimed to offer extensive support, which would lower the threshold of investment cost to the user. Formative evaluation activities conducted during this cycle yielded a number of insights in this regard. Specific comments were offered for each area of the program (rationale, analysis, design and evaluation). The list below summarizes those that pertain to the support offered throughout the entire program:

- Helping users understand basic structure (of the curriculum development process) is an important, though less direct, form of support;

- Offer both 'canned' (ready-made) documents and the opportunity to build one's own (this goes for instruments, plans, etc.);
- In so doing, subject domain links could also be made;
- Ask more prompts and questions, and emphasize why-issues (ask why users make certain decisions, and explain why CASCADE-SEA makes certain recommendations);
- Be sure to include a user manual (text-based guidebook);
- Tell the users where they are at all times, and warn them when they attempt to leave a page without completing certain fields;
- Explore the use of third party applications to expand CASCADE-SEA's functionality, also look for existing materials to add to this system;
- Even if only a few users can access it, link the program to a discussion site; and
- From a constructivist perspective, "show me" or "help me" buttons serve to scaffold and model. Since modeling leads to self-reflection, this is considered conducive to user professional development.

Finally, in terms of the interface being able to reflect flexibility of the system, a number of recommendations were made. Experts recommended considering various versions of the program, such as a separate tour for 'visitors' to the system. Another possibility was making one version for more experienced and one for less experienced users. Technical suggestions related to the structure of meta-data, when putting lesson ideas into a database, and to various options for presenting formatted text (this version presented some documents to users in ASCII format, which is limited, visually).

Prototype 2 cycle results *(cost: 31)*
Formative evaluation activities carried out with prototype two generated insights on the content, support and interface in the design portion of the program. The participants in circuit 14 (hands-on workshop) felt that use of CASCADE-SEA (in this version, called the Lesson Builder) saved them time and effort. Teachers in both workshop circuits (13 and 14) especially appreciated the flexibility in the system that made it possible for them to change or tailor aspects of lesson plans, without retooling the entire documents. A number of improvements were also suggested during this cycle. Teachers wanted to be able to comment on activities, so as to leave additional input for the next user (in the database). They also wanted to see more (volume) in terms of activities and clip art. It was recommended that new users be reminded how to access the tutorial/quick review, and that the graphics program linked with CASCADE-SEA should be easier to use than the current one (Microsoft Paint©). The developer screening conducted during this cycle yielded minor changes and updates for individual screens within this prototype; one general insight (pertaining to multiple parts of the program) was to be sure to give examples from varying subject areas (not just chemistry).

Prototype 3 cycle results *(cost: 32)*
Experts and resource teachers involved with the formative evaluation of prototype three were generally quite satisfied with the amount of information and steps (regarding content and support) included in the program. However, regular teachers noted a number of areas that they considered unnecessary. For example, teachers in circuit 22 recommended leaving out the evaluation part; while those involved in circuit 20 felt that the rationale portion of the program was "superfluous to the needs of the teacher planning on a daily basis." Some participants in circuit 19 expressed the opinion that the design area contains too many steps. For example, a few teachers stated that the title and the topic fields in the build lesson area are actually the same. However, document analysis showed that participants did fill in different answers for these sections (the title was often more specific than the topic). On the other hand, almost all participants in circuit 19 indicated that they felt the design area contains the necessary steps, not lacking any information. In line with previous findings, users determined that CASCADE-SEA is too elaborate for creating only one lesson, and that it needs to be used for developing a lesson series.

In terms of strengthening the support offered, recommendations were again given for individual screens as well as ideas that would impact the program as a whole. This latter list included: additional instructions (particularly in the design area but also in the handbook); more examples (usually with reference to the database); prompts for the user to consider connections to everyday life and extra enrichment (such as 'Did you know?' information, home projects, review questions etc.); and ideas on how to improve the layout of the materials generated with CASCADE-SEA.

Prototype 4 cycle results *(cost: 33)*
Cost-related data collected during the fourth cycle confirmed insights from previous activities. While some participants in circuit 29 felt that CASCADE-SEA was too time consuming, the majority of participants in this cycle indicated that the program saved them time in the long run (although computer literacy was often considered a prerequisite). The bulk of participants also expressed satisfaction with the content and support offered in the program. For example, when asked to respond to the statement that CASCADE-

"Think about the main parts of the program and indicate if you think you would use each section. Assume that CASCADE-SEA is in your SMC, and choose one box for each part of the program."	Rationale	Analysis	Design	Evaluation	Others (toolbox, tutorials, etc.) *
I will definitely use this section	31	34	37	36	20
I might use this section	8	5	2	3	16
I am not likely to use this section	0	0	0	0	0
I will definitely not use this section	0	0	0	0	0

* = Three respondents left this question blank

Box 5.3: Summary of responses (Q-SEITT5b.28, item 10)

SEA offers sufficient information about making materials, 32 out of 41 respondents in circuit 28 agreed (13 of them strongly agreed). Further, participants in circuit 30 were asked to rank the usefulness of the toolbox, manual and auxiliary programs associated with CASCADE-SEA. The clear majority of participants found each of these items to be "useful" (most said "very useful"). For insights regarding how often facilitator teachers anticipated that they would be likely to use the program if it were available to them, see Box 5.3.

Although relatively few new insights were generated during this cycle, other ideas regarding already-raised issues did become more sharply focused. For example, the developer screening yielded the conclusion that the analysis instruments were (generally speaking) longer than necessary, and that they should be either shortened or additional emphasis should be placed on where, why and how users can prune them. Also, participants in circuit 26 discussed - at great length - the pros and cons of a 'lite' version of CASCADE-SEA. While some argued that teachers would be unduly challenged by the complexities of the existing program, others maintained that this was an asset: offering them room to grow. It was argued that a 'lite' version would help to purvey the misconception that curriculum development is simplistic; and undermine the need for attention to intertwined complexities. One individual went on to compare this situation to when a king once told Mozart that he would like to study a portion of his work, but was befuddled by the complexity, saying that there were "too many notes." Mozart replied that he would be happy to remove the offending notes, if the king would be so kind as to articulate exactly which ones they were. In this seminar, participants could not reach consensus as to where to 'draw the line' between a 'complete' and a 'lite' version of the program.

Conclusions and implications regarding the practicality (34)
Throughout the evolution of the various prototypes, insights were gained toward optimizing the practicality of the program. In particular, formative evaluation data enhanced understanding about ways to structure the program, how the program could/should be used, and enhancements from a technical standpoint. In terms of the program's structure, the visual representation impacted user interpretation and understanding with regard to the curriculum development process as well as how to go about it (content and support). Not only was this done by presenting steps to carry out (e.g. main menu), but also by encouraging users to indicate when they were not prepared to carry out certain steps (e.g. "I don't know" check box). Further, optimizing the practicality of CASCADE-SEA's structure proved particularly challenging given the tendency by many participants to want to extend the range of user groups beyond those originally intended. Throughout prototype development, the target user group remained facilitator teachers working in resource centers; yet much of the feedback came from a wider variety of sources. This led to unforeseen discussions, including the

possibility of creating multiple versions of the program, as well as the realization that such a task may sound easier and more valuable in theory than it might prove to be in practice. For example, few regular teachers even want to spend much time creating exemplary materials (they are more concerned with their own lesson planning, and getting it done quickly); and this group has comparatively little access to computers.

Likewise, extending the user group (during formative evaluation activities, *not* with regard to developing the program) gave rise to the insight that this tool might be useful to preservice teachers as well as facilitator teachers engaged in professional development activities. But whether used with preservice or inservice (resource) teachers, the usefulness of the program would, in part, be determined by its availability. That is, the limited access to computers must be addressed for training to make sense. Obviously, computer availability is a pre-requisite for initial workshops to take place. But after that, participants must still be able to access the program regularly and often if it is to offer any added value. One other insight with regard to extending the CASCADE-SEA's group stems from the way it is structured. From the very first prototype, participants clamored about the importance of examples. Decisions on how to incorporate examples into the program were linked to insights regarding CASCADE-SEA's validity. Namely, opinions were mixed with regard to whether or not to include subject matter support; at the same time, it seemed as though when it comes to examples - more is always better. So the decision was made to structure the program with generic (not subject-specific) guidelines and advice, but to offer subject-specific examples, as often as possible. Further, those examples should be as close to the user's own field of expertise as possible. Those participants involved in formative evaluation activities who did not benefit from the relevant content-based examples, still made use of the support. They also recommended that, by adding more examples, the program (and thus the user group) could be extended to other grade levels and other subject areas.

Finally, insights related to technical and interface aspects pertained primarily to screen (layout) design and offering users extensive opportunities for support through additional software. Although certain zones were distinguished in the interface starting with the first prototype (navigation, instructions, interaction, etc.), the practicality of the interface design improved as a result of formative evaluation feedback (e.g. on-screen instructions were further divided into procedural and content-related information). The improved understanding with regard to what CASCADE-SEA should actually aim to do (generated mostly through validity-related data) served to sharpen ideas on where CASCADE-SEA should 'leave off' in terms of offering support. This, in turn, made it easier to judge what types of external programs would be useful additions to the CASCADE-SEA suite.

5.2.3 Impact potential

Better quality materials [10]

Prototype 2 cycle results *(better quality materials: 35)*

No data were collected with regard to CASCADE-SEA's ability to contribute to the creation of better quality materials during the formative evaluation of prototype one. Starting with prototype two (the Lesson Builder), materials developed with CASCADE-SEA were carefully examined. The first sets of materials, created during circuit 35, are included on the CD-ROM at the back of this book (see Appendix J).

When compared to those produced by TEAMS, the materials produced with CASCADE-SEA share a very similar structure in terms of content areas and support offered to the teacher. The CASCADE-SEA-made materials appear easy to use; the plan on 'Acid-base titration' even includes a learner homework sheet. The materials produced with CASCADE-SEA target subject areas that were deemed appropriate by the development teams at the workshop (chosen based on challenging areas of the syllabus). Further, they appear to contain state-of-the-art knowledge regarding the topics of Mendelian inheritance; acid-base titration; and endothermic and exothermic reactions. They are internally consistent; and they offer sufficient guidance to the teacher (although they do vary in degree of detail). These materials contain clear, useful procedural specifications, but it should be noted that, although CASCADE-SEA does try to stimulate this, the user is more responsible for this fact than the program. Finally, the materials produced with CASCADE-SEA evidence that attention has been given to form and style, through a clear (at-a-glance) layout. Participants in this cycle indicated that they appreciated the framework CASCADE-SEA provides for the teacher to build these lessons. They also recommended a number of enhancements with regard to formatting the design templates (upon which the materials are based).

Prototype 3 cycle results *(better quality materials: 36)*

Data collected during formative evaluation activities with prototype three indicated that CASCADE-SEA has the potential to contribute to the creation of better quality materials (see Box 5.4), but that the potential could even be extended further. For example, 25 out 27 participants in circuit 19 indicated that they felt the lesson materials made with CASCADE-SEA are more structured than those

> "CASCADE-SEA definitely gives direction as to how to generate an improved lesson."
> - *Teacher (circuit 23)*

Box 5.4: Teacher citation

[10] Better quality materials refers to: the materials developed with CASCADE-SEA should be valid, practical and effective; they should contain clear, useful procedural specifications; they should evidence that attention has been given to form and style.

made without the aid of the computer. Further, three of the four experts explicitly stated that they thought better quality materials would be made by using CASCADE-SEA, as compared to the materials developed without CASCADE-SEA. The fourth expert said that the quality of materials would be good (but not per se better) because CASCADE-SEA guides the teacher completely through the curriculum development process. In circuit 21, involving preservice teachers, both students and lecturers from teacher training colleges evaluated the lesson materials created by the preservice teachers. They indicated that the materials show a similar or greater depth than those produced by student teachers without the aid of CASCADE-SEA, and although the materials offer sufficient guidance to the teacher, some points could still be improved. A sampling of lecturer (open) comments is shown in Box 5.5. Due to technical difficulties (including construction work being done in the adjacent room and resulting power failures in circuit 22), participants in circuits 20 and 22 were unable to complete their lesson plans in most cases. Because they are incomplete, plans made during these circuits do not offer sufficient guidance to the teacher. This cycle also yielded recommendations for improving the quality of the materials generated with CASCADE-SEA. Mainly, it was thought that greater attention should be given to what the learners ought to be doing during a lesson. For example, outcomes for the students should be more carefully specified. Finally, participants recommended encouraging the CASCADE-SEA user to consider (on behalf of the learners) higher reasoning skills and local applications/relevance.

Physics plan comments
"Very good plan; includes all relevant aspects in teaching a lesson; need to include motivational techniques in lesson plan."
- Physics lecturer

Chemistry plan comments
"Too many objectives for allocated lesson time."
- Education lecturer

Mathematics plan comments
"Very well structured plan; user did not set standards for measuring objectives; for example, the user did not state to how many decimals the students need to specify their answers."
- Mathematics lecturer

Box 5.5: Lecturer citations

Prototype 4 cycle results *(better quality materials: 37)*

During this cycle, participants were asked to offer their opinions with regard to CASCADE-SEA's ability to promote the creation of better quality materials (compared to those created without the aid of the computer). Results during this cycle confirmed the findings of previous ones. For example, all three (science) teachers involved in circuit 27 indicated (two strongly indicated) that they thought CASCADE-SEA can lead to better quality lesson materials. Likewise, when asked to respond to the following statement, "I think CASCADE-SEA can lead to better quality lesson materials" 40 out of 41 participants agreed (of which, 24 strongly agreed), and one participant was neutral. Those involved in circuit 29 were a bit more skeptical, but overall, still positive in this regard. Finally, all participants who answered the question in circuit 30 (one did not respond) said that they make better quality lesson plans by using CASCADE-SEA than they do without using the program. A few of the reasons given were: *"it focuses the teachers on all aspects relevant to lesson design; it is very detailed, deepening and informative; I used not to have a direction before; because [CASCADE-SEA] supplies me with good quality of ideas and it guides me on how to use them."* No improvement suggestions (directly related to better quality materials) were generated in this cycle.

Enhances professional development [11]

Prototype 2 cycle results *(enhances professional development: 38)*

Evaluation of the potential for CASCADE-SEA to contribute to user professional development was not explicitly addressed during the formative evaluation of prototype two, as doing so was considered premature at this stage. However, some responses to an open question (Q-TEAMS3.14) asking participants to indicate the strengths and weaknesses of this prototype pertained to CASCADE-SEA helping users think about materials development in a (more) systematic and fashion. Two teachers referred to the notion that their work would be systematic when using the program. Three participants spoke of how the program reminds teachers of their responsibilities which might ordinarily not be considered during planning and two others commented on how the computer helps one to be well-prepared, noting that demonstrations and experiments were encouraged through the program. However, observation data (O-TEAMS3.14) from this cycle showed that participants were reluctant to articulate weaknesses in the program, since they seemed to feel that they might be able to be more critical when they learn more about computers. Further, participants indicated that their lack of exposure to any other lesson preparation programs made it difficult for them to offer appropriate criticism.

Prototype 3 cycle results *(enhances professional development: 39)*

Although opinions were mixed as to how, participants in cycle three generally agreed that this program does have the potential to contribute to the professional development of its users. This is reflected in the recommendation to integrate this program in preservice activities (mentioned in circuits 16, 21, and 24) as well as inservice activities (mentioned in circuits 16, 19 and 23). Different participants naturally saw different values for doing so. For example, the process of generating a rationale profile was seen to be a valuable learning process for the students in cycle 21. It connected very well with what they had learned about curriculum development; and, according to them, it was the first time they

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[11] Enhances professional development refers to: CASCADE-SEA should help users to think about materials development in a (more) systematic and thorough fashion; teaches users where resources can be found (inside the program) and how they may be used/adapted for one's own setting; interface helps (teams of) users to visualize the process of materials development and make their work more transparent.

had a chance to reflect on their own educational philosophy and values. In contrast, the facilitator teachers involved in circuit 19 particularly appreciated the evaluation component of the program (which appeared to be a new phenomenon to most users). Those who had worked on the program individually said, during the discussion, that it made them reflective. Similarly, observation showed that participants working in groups were quite talkative during activities, reflecting upon the process as offered by CASCADE-SEA. Finally, three out of four experts involved in this circuit indicated that CASCADE-SEA offered them new ideas for curriculum development. The fourth expert said he was unsure about new ideas, but that it did help to organize things.

Although specific enhancements in the program were not mentioned by external participants (toward improving CASCADE-SEA's ability to contribute to user professional development), comments on the workshop activities were useful in this regard. Participants felt that the workshops could have been improved by: having more computers available for individual practice; having more time to work through the program; having more time to discuss things thoroughly; and offering training for relevant technical skills. Additionally, the developer screening yielded two recommendations for improvement in this area: revisit literature on teacher professional development for ideas on ways to support this; and explicitly try to support cooperation and group planning.

Prototype 4 cycle results *(enhances professional development: 40)*
Findings during this cycle again confirmed those from earlier cycles. The majority of experts and users indicated that they thought CASCADE-SEA possessed the potential to contribute to user professional development (see Box 5.6). Most participants in this cycle felt that the program helps users to think about materials development in a (more) systematic and thorough fashion. Teachers (27 out of 29 in circuit 28) also felt that CASCADE-SEA will help contribute to better teaching on the part of those using lesson materials made with CASCADE-SEA. Finally, some participants in circuit 29 felt that the use of CASCADE-SEA has led to more group work (among student teachers) as well as increased collaboration (among teachers in the regions).

> "I find the main value to be teacher training and through that - collaborative lesson development (perhaps during inservice training). "
>
> *- Education Officer*
> (Ministry of Basic Education and Culture)
>
> "[CASCADE-SEA is] usable in teacher colleges and inservice programs...It gives easy level guidance and helps for teachers and curriculum developers also, students learn in a meaningful way how to build up lessons. "
>
> *- Representative*
> (Namibian Institute for Educational Development)

Box 5.6: Expert citations (circuit 26)

Conclusions and implications regarding the impact (41)
Compared to the quality aspects of the validity and practicality, little data were gathered pertaining to the impact potential of CASCADE-SEA during the

design phase. In part, this is because honing the validity and practicality was considered a pre-requisite to being able to explore the impact potential. Therefore, these other two aspects were given precedence during formative evaluation activities in the design phase. Further, this aspect is difficult to measure through the relatively short-term (one week or less) activities that were undertaken during these circuits.

Nevertheless, the data collected during the design phase showed that CASCADE-SEA does have the potential to make a positive contribution. Participants and researchers judged (most of) the materials produced with CASCADE-SEA to be of equal or better quality than those produced without the computer. They did, however, comment that the materials could offer additional support to teachers in terms of what the *learners* should be doing during lessons (as opposed to mostly providing guidelines for what the teacher should do). In addition, the vast majority of participants (who commented in this regard) shared the opinion that CASCADE-SEA has the potential to contribute to the professional development of its users. This was seen to be particularly relevant for preservice and inservice participants involved in a professional development program (as opposed to those using the system independently). However, most participants involved during the design phase had little previous exposure to any form of computer supported curriculum development. Without any similar experience for comparison, it may have been difficult for these individuals to imagine what CASCADE-SEA could be missing, or how it might be improved. But what participants were able to do (and did) was comment on the quality of the workshops. Although no great surprise, this implies that CASCADE-SEA's ability to contribute to professional development (in particular) is partially dependent upon the way in which it is implemented.

5.3 Evaluation: Achieved it?

The semi-summative evaluation phase of the study mainly examined the impact of the CASCADE-SEA system in terms of potential contributions to curriculum development and teacher development resulting from its use. This phase also touched on generating ideas for continuing this line of inquiry in the future, and explored potential uses for CASCADE-SEA outside the realm of the original intentions. The semi-summative evaluation was composed of two cycles: a final evaluation (three circuits) and an exploratory query (one circuit). The query was conducted with two goals in mind. To a lesser extent, this activity contributed to answering the main research question; but the foremost aim was to explore options for follow-up research. Because this query pertained primarily to future directions regarding this line of inquiry, it will only be addressed in limited fashion in this chapter (please refer to Chapter 6 for additional information regarding the query). Data were collected during this phase through the expert appraisal, micro-evaluation and tryout strategies. The three final evaluation circuits involved participants from Tanzania (circuit 31), the Netherlands (circuit 32) and Namibia (circuit 33); the query circuit invited (and received) input from interested parties in many different countries in North America, Europe, Africa and Asia. The remainder of this chapter describes the results of the semi-summative evaluation phase.

5.3.1 Validity

State-of-the-art knowledge

Final evaluation cycle results *(state-of-the-art knowledge: 42)*

As previously mentioned, the main focus of the third phase of the study was to explore the impact potential of CASCADE-SEA. But because the quality aspects of validity and practicality were considered pre-requisites for doing so, these were also examined briefly, in circuits 32 and 33. Participants in circuit 33 (facilitator teachers) were clearly more positive about the state-of-the-art knowledge contained in CASCADE-SEA than those in circuit 32 (experts). Besides expressing general satisfaction, the users offered relatively few comments with regard to the content (curriculum design and development knowledge contained inside the program). In contrast, the experts commented on both the strengths and weaknesses of the program's content. Frequently mentioned strengths included: the systematic, comprehensive and wide-ranging avenues (for materials development) the program offers; the level of detail and "enormous amount" of knowledge, information and tools contained inside the program; and the inclusion of information to assist with implementation was also noted as a particular strength. However, expert opinions were far from unanimous. Aspects listed by some as strengths were noted by others to be weaknesses, for example, *"[CASCADE-SEA is] too 'rich' for the target group - cut out some essentialities…Africa is in need of guidelines."* Further, some participants felt that CASCADE-SEA offers only one paradigm for curriculum design and development, and that this paradigm does not reflect state-of-the-art knowledge in the curriculum domain (e.g. *"I miss the newest ideas regarding constructivist design,"* commented one participant). There was increased (although not complete) consensus on the notion that CASCADE-SEA should emphasize the design phase more. Lastly, a number of experts questioned whether the subject matter (contained in the examples) was valid (state-of-the-art knowledge).

In terms of the support offered inside the program, the expert group expressed the opinion that this program was not for use by individuals (for daily lesson planning). In accordance with this reasoning, the user group indicated that CASCADE-SEA might be used in inservice education at resource centers. Participants in circuit 33 (users) appreciated the advice on materials design, citing the knowledge gained and help offered (e.g. *"it* *made my lesson preparation easy"*) as the two greatest assets. The expert group also commented on the "good overview of what you have to think of" but recommended that the system should offer more support on (re)design; that is, designing from existing material. Further, this group offered recommendations for embedding the creation of lesson materials in professional development programs. Namely, they said that much of the support inside CASCADE-SEA is implicit, *"... we think that (especially where it is meant to be a learning tool) it [the support] should be made more explicit."* One participant questioned whether or not CASCADE-SEA can contribute to self-reflection, and (if it does) if self evaluation can be a viable form of staff development. Finally, one participant's comment aptly summarizes the variety of opinions discussed during the workshop; this statement is in Box 5.7.

> "The comprehensive generic nature is a strength and a source of weakness. There is a bit of a barrier to opening up a massive program if the task at hand is very specific. One might tend to use the pen and paper or Word, instead."
> *- Education in developing countries expert (circuit 32)*

Box 5.7: Expert citation

Both groups also offered feedback with regard to the interface and technical aspects of the program. The user group identified certain screens in the program that did not maximize the potential of modern ICT facilities; for example, they were frustrated with the inability to input multiple-line entries into text boxes. The expert group offered more general commentary in this regard, as evidenced in the list below:

- CASCADE-SEA does not maximize ICT facilities, and it shouldn't, as many users and PCs are ill-equipped;
- A technically light version is recommended: one that runs quickly and easily (on older computers);
- A web-based option is recommended; and
- Explore improvement of multiple-user database sharing and access.

They also raised some questions for consideration: *"Could the interface be more flexible/adaptable?"* and *"Does the form [of CASCADE-SEA] fit the function?"*

Query cycle results *(state-of-the-art knowledge: 43)*

Although participants in the query were generally more enthusiastic about the state-of-the-art knowledge contained in CASCADE-SEA when compared to those in the previous cycle, their feedback provided few new insights in this area. Main strengths listed by the participants included: clarity; thought-provoking questions; made planning easy; and good science content. One participant elaborated on the program's strengths by saying this: *"[CASCADE-SEA] is comprehensive. It takes the user through the complete cycle of curriculum development - from conceptualization through development and back to re-conceptualization. For a person like me who does not have a background in curriculum development, this is a good 'one stop shop' to understand the basics and get the tools to prepare a lesson*

> "The structure illustrates a multi-level perspective. I can see the forest, the trees and the leaves all in one."
> - *Lecturer (circuit 34)*

Box 5.8: Survey participant citation

series/plans. Also, it is logical in its structure." The value of the structure was also noted by another participant, a university lecturer in instructional design (Box 5.8).

Along with their enthusiasm, participants in this cycle also listed weaknesses with regard to the state-of-the-art knowledge, particularly the volume. *"While being comprehensive and logical, [CASCADE-SEA] does not seem intuitive. A new user, especially someone who is new to curriculum development, is likely to get a bit confused,"* said one participant. Ironically though, many participants wanted to see more (content), particularly in terms of examples. Similarly, a number of participants commented on the fact that CASCADE-SEA can be overwhelming, particularly for new computer users: *"it takes a lot of time to focus, if one is still learning the manipulation of computers."* From a technical perspective, some (n=3) participants experienced the program to be temperamental/unstable.

Internal consistency

Final evaluation cycle results *(internal consistency: 44)*

Very few comments were given with regard to the internal consistency of the program during the final evaluation cycle. The bulk of the data collected during this cycle came from the expert workshop in circuit 32. In terms of CASCADE-SEA's content, a number of experts indicated that they felt consistency inside the product was weak. They felt that the program does not guard against inconsistent answers/responses; and that the differences in the levels addressed are perhaps too broad (saying that goals are abstract, while lesson contents are specific). Finally, there were mixed opinions with regard to the relationship between the rationale and other components (particularly design) of the program. Many experts felt that the link was not present; while others termed it a "loose coupling, sometimes caused by common sense" without a direct (one-to-one) the relationship. This group indicated that the interface was consistently designed, but said that more use should be made of the visual support for the design process.

Query cycle results *(internal consistency: 45)*

Similarly, internal consistency-related results from the query were minimal. The main issue in this area, raised by a number of participants, pertained to the relationship between the rationale and other components in the program. Simply put, these reactions varied greatly, as emphasized by the following (contradicting) comments:

- "Forces thoughts, goals, aims to be organized; curriculum format is helpful - everything is linked and reverts back to the other (i. e. rationale is tied to design, design is evaluated based on rationale, etc.)"

  \- *Teacher and graduate student, USA*

- "There is no evident way to connect the items within the rationale profile into the lesson plan (if learner centered teaching is one of the rationales of the materials being prepared, it is not clear how the user can incorporate it by working with the lesson builder in [CASCADE-SEA])."
  - *Educator working at NGO, India*

Conclusions and implications regarding the validity (46)
With regard to the validity of the program, the main question during the semi-summative evaluation phase was, "were the desired quality aspects achieved?" Namely, does CASCADE-SEA contain state-of-the-art knowledge and is it internally consistent? The data collected during this cycle illustrates that answering these questions is not as simple as deciding between a 'yes' or a 'no.' For example, most participants encountered state-of-the-art knowledge inside CASCADE-SEA, as evidenced by their classification of the program as systematic, comprehensive, rich, clear, thought-provoking and logical. But some participants considered the strengths to be simultaneous weaknesses, saying that CASCADE-SEA could be overwhelming and confusing particularly to those who are new to either curriculum development, computers, or both. Further, the experts (particularly those in the field of curriculum) expressed concern about the lack of variation pertaining to the curriculum design and development paradigms in the program. And some further stated that CASCADE-SEA does not reflect state-of-the-art knowledge in the curriculum domain, citing reasons that implied it being either too traditional or at least, not modern enough (e.g. "not constructivist"). With regard to internal consistency, the main issue raised by participants, whose opinions were varied, was the relationship between the rationale and the rest of the program. It is difficult, if not impossible, to discern whether the lack of additional comments on internal consistency points to satisfaction (if there is little room for improvement, there may be few comments), or indifference to the topic. Either way, it is also the case that the semi-summative evaluation phase was mostly geared toward learning about the program's impact potential, with practicality and validity issues having been addressed more extensively in earlier phases of the study.

But, based on the data that were collected, two main conclusions may be drawn with regard to the validity of CASCADE-SEA. First, state-of-the-art knowledge is contained in the program, but choices regarding the volume (possibly too much) and types (possibly not modern enough) are questionable. Second, while very few participants pointed out specific inconsistencies in the program, the general -though not unanimous - consensus (mainly of the experts in the final evaluation cycle and query participants) was that this aspect is present, but weak. This was noted in particular regard to the support that links the rationale and the rest of the components.

As mentioned earlier, validity issues were not examined in isolation from those pertaining to practicality. For example, decisions concerning the volume and type(s) of state-of-the-art knowledge contained in CASCADE-SEA were influenced by insights from the context in which the system was to be used. The next section looks at how well those insights were implemented, in terms of CASCADE-SEA's practicality.

5.3.2 Practicality

Instrumentality

Final evaluation cycle results *(instrumentality: 47)*

During the final evaluation cycle, practicality data were collected during each of the three circuits involved (31, 32, 33). Most participants in all three circuits indicated that, in their opinion, CASCADE-SEA guides the user step-by-step in making materials. Participants in circuit 31 were able to follow the on-screen instructions, but did not hesitate to ask for clarification when desired. It was often mentioned in circuits 32 and 33 that CASCADE-SEA suggests steps that might not otherwise occur to the user. Most participants found this to be a major strength (saying that it "broadens your horizons" in circuit 32 and that *"You'll even realize what you haven't think about before,"* in circuit 33); but a few experts pointed out that this can be distracting. In terms of allowing freedom to work at one's own pace and style, opinions were somewhat mixed. The materials developers working in Tanzania (circuit 31) worked at their own speed, some dividing up tasks and some staying in teams, throughout the week. Similarly, the facilitator teachers (circuit 33) felt that CASCADE-SEA *"... helps guide teachers on what they're supposed to do though it does not prescribe what exactly to do."* However, one teacher expressed frustration at *"using other ideas, rather than own's."* Expert opinions were also varied. Whereas most participants felt that the program does allow users to work at their own pace, mixed feedback was given with regard to personal style. One participant said that the program may, in fact, "block" creative ideas, although another participant pointed out that skipping over (undesired) steps is "very simple" to do.

With reference to clear and concise explanations of how to use the program (support), data collected during this cycle showed that most participants (in each circuit) understood the content and procedures in the program. Generally speaking, however, the majority of participants in circuit 33 requested additional explanation (besides that which was offered inside CASCADE-SEA). The expert group additionally commented that some of the texts in the program could be polished, with particular attention to length (some were considered too long) and terminology (use of language) which some thought to be "too complicated for the target group." One expert said that *"explanations are clear...[but]...a second language speaker (especially in* *the African context) may find some of the language convoluted and slightly jargonized (e.g.: lab, clip art)."*

Finally, with regard to the clarity of the interface, it was noted that even those participants with few computer skills were able to learn their way around the program fairly quickly during circuit 31. However, observations from this circuit as well as (varied sources of) data from other circuits emphasized that this program does not speak for itself. Introduction workshops are necessary, especially for new computer users.

Query cycle results *(instrumentality: 48)*
Participants involved in this query commented on CASCADE-SEA's step-by-step guidance in making materials. They said that the program is logical and contains "discrete components, which are self evident." But despite its "user-friendly" and "easy to follow, step-by-step" nature, a number of participants found the interface to be complex and the "lingo" to be a challenge. Particularly for new computer users, training and a manual were considered necessary.

Congruence
Final evaluation cycle results *(congruence: 49)*
All three circuits within this cycle examined how CASCADE-SEA does (or does not) link up with contextual realities. In terms of the needs and wishes of the users, 16 out of the 19 participants in circuit 31 said that they would be interested in using CASCADE-SEA in future workshops. Participants in circuit 33 were similarly enthusiastic, and one participant noted, *"teachers must be motivated to use both approaches [the traditional way of creating materials and CASCADE-SEA] in creating exemplary materials."* Data collected during circuit 32 was limited in this regard, although experts generally felt that (with training) the support would be relevant and usable. Participants in circuit 33 echoed this sentiment as illustrated here: *"CASCADE-SEA is not a stand-alone solution; it is a support tool that will be used within the existing procedures of developing lesson materials."*

Another participant in circuit 33 emphasized the importance of the fact that the program has been designed with limited resources in mind, saying that a shared resource such as this one would ideally be "strategically deployed" on the few available computers (at resource centers). Most facilitator teachers in this circuit expressed concern about the lack of computers and ICT expertise. Said one: *"Since most schools in our circuit have an acute shortage of materials to support instruction, CASCADE-SEA in my view would be an ideal tool. But…current realities such as teacher computer literacy level, availability of computers and experts to train teachers will have to be addressed. Additional facilities such as those ones at Ponhofi would have to provide teachers with literacy skills and knowledge on computers and information technology in general. Staff development in this circuit would be* *a crucial condition for successful implementation."* Although this presents an immense challenge, a materials writer in circuit 31 was encouraging. *"Look at me,"* he said *"I knew nothing of the computer before this week, and now I have made materials on it."* Most participants in this circuit did, however, comment that a week was too short. Finally, each of the three circuits in this cycle also yielded information with regard to the interface, and how it 'feels' to the user. Participants in circuits 31 and 33 said that they were generally happy with the interface, and blamed any frustrations on their lack of computer knowledge. Experts only offered three comments in this regard, they were: some of the sequencing (where explanations are given) could be improved; too much use of pastel colors and ⓘ (information) files; and *"present version is a massive improvement on early prototype but still requires a degree of computer competence not always found in the target group - getting very close though."*

Query cycle results *(congruence: 50)*
The query asked participants to consider how the program connects to their own settings, not to that of the target audience (science and mathematics resource teachers in southern Africa). Therefore, congruence data from this circuit is not relevant to the discussion of whether or not CASCADE-SEA achieved its goal. Discussion of this issue in terms of future research is addressed in Chapter 6.

Cost
Final evaluation cycle results *(cost: 51)*
All three circuits in this cycle yielded similar data with regard to cost. In circuits 31, 32 and 33, opinions were mixed in terms of the amount of time necessary to use the program: participants described CASCADE-SEA as "most efficient" and as "time consuming." Specifically, the expert group in circuit 32 found the analysis component to be too detailed. Most participants appreciated the database function and recommended that support could be extended by enriching this aspect ("more good examples"). One participant (circuit 33) warned, *"CASCADE-SEA may make lazy teachers more lazy as they will think they don't need to read books for preparation anymore."*

Most participants expressed satisfaction with the flexibility of the system; although there were those who felt that the program offered too much structure. Discussion (during circuit 31) took place regarding whether or not the structure in the program was 'required' or 'suggested.' Experts in circuit 32 suggested that novice users need even more structure and that coaching, in addition to time investment (introductory workshops, etc.), would be desirable. Participants in circuit 33 said that CASCADE-SEA offers a "very flexible way" of working on materials and that the user is "free to make certain adjustments that are more applicable to [one's] own context or situation." Finally, one participant in this circuit wrote, *"people who are at a certain level on the dissemination of information, such as the facilitators,* *will find the program more useful than the teachers. Teachers will have a time constraint and may not satisfy all the demands which the [CASCADE-SEA] program advocates, they would thus be choosy and very selective thereby skipping a lot of items when using it."*

Query cycle results *(congruence: 52)*
Participants in the query offered similar comments to those mentioned in the previous cycle concerning the costs associated with using CASCADE-SEA. Additionally, they were particularly appreciative of the external programs (Mindman©, etc.) that come "all in one package" and they felt that the opportunity to export files and edit them made things quick and easy. A number of query participants commented that they felt this tool is not realistic for classroom teachers (primarily because, for daily planning, it is excessively time consuming), but that it would be appropriate for teacher education.

Conclusions and implications regarding the practicality (53)
The semi-summative evaluation of CASCADE-SEA's practicality yielded a number of insights about instrumentality, congruence and cost. Participants in this cycle generally felt that CASCADE-SEA offers step-by-step guidance to the user, but in some cases, perhaps too much. Whereas most participants expressed satisfaction in terms of the pace with which they could use the system, there were concerns that the computer's advice would be over-bearing. Also, the language used was thought to be a challenge for many users. It was generally (though not unanimously) agreed that the program can/should not be used independently, but that it should be introduced in a training setting, along with the user manual and perhaps even coaching. Despite relatively minor comments about the interface (that were not shared by many participants), most participants felt that CASCADE-SEA connects with the needs, wishes and context of the target users in terms of content and support. It was emphasized that this should be seen (and used) as a shared resource to supplement existing activities in materials development. In fact, particularly due to the time investment required, virtually no applications for daily lesson planning were identified. As for the time investment for the creation of exemplary lesson materials, opinions were mixed. For the issues where no consensus was reached (especially user personal style and temporal investment), it follows logically that these are subjective interpretations based on individual needs/wishes.

5.3.3 Impact potential

Better quality materials
Final evaluation cycle results *(better quality materials: 54)*
Each of the three circuits during this cycle addressed the question of whether CASCADE-SEA contributes to the creation of better quality lesson

materials. The materials developers in circuit 31 were asked to rate the quality of materials they had created with CASCADE-SEA. Three out of the five participants who worked intensely with the system during the week answered, "better than those made the usual way" and two indicated "equal to those made the usual way." When asked for further specification, three out of the five said that materials created with CASCADE-SEA were more up-to-date, three out of the five said they were more practical, and three out of the five said they were more effective than those made the usual way. Of the other two participants, one consistently said, that the these factors were dependent on the user (thus, neither better nor worse); the other participant did not answer the question relating to effectiveness, but said that materials made with CASCADE-SEA would be less up-to-date and less practical than those made the usual way. When asked whether or not the lesson materials created with CASCADE-SEA were more or less internally consistent than those made the usual way, two teachers said more; two teachers said neither; and one said less. The two teachers that said neither elaborated with these comments: "Depends how rich the database is" and "because lesson materials are up to date regardless [of whether or not CASCADE-SEA is used]." The experts involved in circuit 32 echoed the sentiments of the participants who consistently replied "neither" in circuit 31. In essence, they felt that CASCADE-SEA might have the potential to contribute to (more) valid, practical and effective materials (e.g. by preventing "haphazardness") but that this depends on two things: how the system is used; and the capabilities of the user. Finally, participants in circuit 33 consistently commented that the materials they created with CASCADE-SEA were of high quality. The majority also implied, but did not always directly so state, that the quality was better than the materials they had made without the computer, e.g. *"The lessons are by far more detailed."*

The expert group offered no comments pertaining to whether or not the materials created with CASCADE-SEA contained procedural specifications. However, when asked to indicate whether the lesson materials created with CASCADE-SEA contain clear useful procedural specifications for the teacher, all five materials developers in circuit 31 responded yes. Similarly, one participant in circuit 33 wrote, *"If care is taken when introducing the CASCADE-SEA program then it will definitely benefit the users and eventually lead to the improvement of teaching, which in turn will lead to the desired educational outcomes of the learners."*

In addition, data were collected regarding the layout of the materials. Few experts responded to this question. The ones who did appeared to interpret the question differently than intended, as illustrated by this poster comment: *"there is much more to consider in terms of giving form to instruction then fonts and colors."* The user groups involved in circuits 31 and 33 were both satisfied with the layout of the materials produced by CASCADE-SEA. This was evidenced by the fact that participants generally maintained the pre-formatted layout for their materials (although they did add to it) as well as by their comments in this regard, e.g. *"they are well formatted but they are flexible to use and [one] can adjust [them] to his or her preference."*

Query cycle results *(better quality materials: 55)*
Generally speaking, query participants also possessed the opinion that the use of CASCADE-SEA could contribute to better quality lesson materials. They cited a number of reasons as to why, such as *"CASCADE-SEA does integrate curricular development and teaching concepts, so it should help in better creation and implementation of curriculum and lessons. It offers a range of independent modules, instruments and tools which the user can selectively use to improve his/her work."* The ability to share work with others was also listed as a reason for improved quality. While some participants were more emphatic about this aspect, (e.g. "it will certainly lead to better lessons..."), others placed more responsibility on the user (e.g. "... should demonstrate improved performance").

Enhances professional development
Final evaluation cycle results *(enhances professional development: 56)*
Participants in all three circuits concurred that CASCADE-SEA has the potential to contribute to the professional development of its users. Further, they all (generally) agreed that the program helps users to think about materials development in a (more) systematic and thorough fashion. For example, when participants in circuit 31 were asked whether they thought this program could contribute to the professional development of its users, all five (of the intense users) answered yes. In addition, four out of five of them indicated that CASCADE-SEA has caused them to think in a more systematic way and five out of five said that it supported them to be more thorough/detailed. Participants in circuit 33 were also generally positive in this regard although one participant and did say at one point, *"[CASCADE-SEA] makes me reluctant to think."* Finally, the 'education in developing countries' expert sub-group suggested that this program has potential as a learning tool for training, for both preservice and inservice education. But they did emphasize that more time and reflection are needed (when compared to the one-morning session that they had). On the other hand, the 'curriculum development' expert sub-group said, *"We don't think that this program would prevent improvements in the areas of curriculum development and professional development, but as to whether or not it can make a contribution: that depends on how the system is used."*

When asked whether participants in circuit 31 thought that they/their institutions might like to use CASCADE-SEA in the future, five out of five said, "yes." Further, when asked whether or not the participants, themselves, had learned anything about adapting materials for their own setting with the aid of this program, all five checked the box labeled "yes."

The expert group recommended that additional (external) resources be added or linked to the program. One expert said that CASCADE-SEA materials *"seem not (yet) changeable."* Most of the participants in circuit 33 were enthusiastic about the resources found inside the program, but one warned that it might promote laziness or dependency (on the system) among certain teachers.

In terms of how the interface helps (teams of) users to visualize the process of materials development and make their work more transparent, the expert group generally felt that this was not the case. They said that CASCADE-SEA helps, but that it is difficult to gain an overview of the process as a whole. In contrast, five out of the five materials developers in circuit 31 said CASCADE-SEA helps (teams of) users to visualize this process of materials development; and five out of five said it "helps to make this work more transparent to us and others." Further, four out of five said "it is easy to follow." Moreover, zero out of five said that the program was (to any extent) complicated, confusing or frustrating. Participants in circuit 33 also indicated that they had learned about the process of curriculum development through CASCADE-SEA's structure. They listed things that they had learned about the process of materials development such as "...ways I can use to evaluate my materials."

Query cycle results *(enhances professional development: 57)*
Query participants found it difficult to say, with any certainty, whether or not CASCADE-SEA would enhance the professional development of its users. Yet those who commented in this regard did state that they thought it could do so. As one participant said, *"it is a completely different instrument, challenging, and has great potential for improving the overall outlook of the user."* A number of participants did emphasize that the program is "not aimed at the classroom teacher audience." And some listed more appropriate (potential) settings such as in a graduate program that accents classroom action research, or in more general terms, *"the program enables users to reflect on a wide range of aspects of probably much more than they would consider by themselves. As such it is a powerful learning tool."*

Conclusions and implications regarding the impact (58)
The data collected during this cycle yielded the overall conclusion that CASCADE-SEA does possess the potential to have a positive impact on the performance of its users, but that said potential is strongly influenced by how the system is implemented and personal characteristics of those using it. Although not unanimously, most participants in this cycle felt that using CASCADE-SEA can help users to create better quality materials than they would on their own. At the very least, there were no findings to indicate that the program could have a negative effect on the quality of the materials. The structured nature of the program was seen to help participants articulate (in the form of procedural specifications) useful

guidelines for the materials user; and the layout (of the materials created with CASCADE-SEA) was judged to be conducive to easy use. Improving the examples (especially, enriching the database) is one area in which improvement was repeatedly recommended. With regard to enhancing the professional development of users, most participants in this cycle emphasized that the *potential* does exist, but whether or not this is realized again depends on *how* the system is used. In any case, the value of the program as a learning tool (for preservice or inservice education) was rarely, if ever disputed. Stifling user creativity or encouraging laziness was mentioned as a caveat, although not often.

5.4 How findings contributed to program development

In addition to design principles (foundational tenets in section 4.1; development guidelines in section 4.2; and product specifications in section 4.3), Chapter 4 offered a detailed description of the CASCADE-SEA program, after briefly describing the previous prototypes. This section illustrates how activity circuit data were used to inform CASCADE-SEA's development. Due to the volume of data regarding the multiple versions of the program, a comprehensive presentation of such influences (on program development) would be inappropriate for this book. Instead, selected examples of (re)design decisions based on the findings are offered in this section to portray the *nature of the interaction* between the data collected and the growth of the program (including design ideas). First, attention is given to the manner in which the findings were weighed and interpreted; then, examples are given to illustrate participant influences on the growth of the CASCADE-SEA program.

Section 3.5 described the data analysis process in terms of data reduction and classification (according to existing schemes based on the main research question, as well as through recognition of emergent patterns). As described in the beginning of this chapter, reporting decisions were made based on three guidelines. These pertained to *data weight* (as discussed in section 3.4 this relates to the salience and intensity of participant comments); *frequency* (statements that were repeated across circuits were included, regardless of individual circuit weight); and *repetition* (once such patterns are reported, further comments of a similar ilk are noted, but not described in detail again). While the third guideline (regarding repetition) pertains mostly to brevity of the chapter, the first two (data weight and frequency) also depict the basis of interpretation and application of the findings.

In addition to the weight and frequency of the data, careful examination was also given to the pertinence of its source. As discussed in Chapter 3, two main types of participants have been involved in this study: user groups (preservice teachers, inservice teachers and curriculum developers) and expert groups (in science education [particularly in developing countries], in curriculum development and in performance support). For certain types of data, comments from some participant groups were more (and less) informative than others, in terms of the overall aim of the study. For example, the majority of performance support experts had little experience working in southern Africa, but most were familiar with the field of curriculum development. Therefore, the researcher/developer tended to attribute more credence to this group's validity-related comments on the content, support and interface ideas than to practicality-related ones (especially pertaining to congruence). Nevertheless, there were exceptions; some particularly insightful individuals offered suggestions, asked provoking questions or raised issues related to areas outside their (to the researcher) known area of expertise. Similarly, preservice teacher comments were more useful toward gaining an understanding of contextual factors, than they were toward understanding, for example, CASCADE-SEA's appropriateness for the target group (facilitator teachers). Hence, participant input was not integrated immediately nor blindly into the program (and, due to conflicting opinions in many cases, this would have been impossible). Rather, (re)design decisions were the result of careful evaluation of overall participant views together with literature-based recommendations (such as the foundational tenets and development guidelines described in Chapter 4). Ultimately, additions and revisions were gauged by their (anticipated) contribution to meeting the main aim of the tool: to promote curriculum development and the professional development of resource teachers.

Because individual influences of research findings on CASCADE-SEA's design would be too numerous to mention, the following tables contain *illustrations* of how the research activities contributed to achieving the desired quality characteristics. They are comprised of carefully selected examples from each phase and cycle of activity, related to all three quality aspects (validity, practicality and impact potential) and all three program characteristics (content, support and interface). Associated with each attribute introduced in Table 3.1, a vignette is given that recounts design or revision decisions made, based on participant input. For easy reference, the numbers shown in parentheses correspond to the cells in Table 5.1, as well as the headers used throughout this chapter. This information additionally allows for the location of the relevant data summary documents contained on the CD-ROM at the back of this book. (For clarification on how to do this, please refer to the explanation following Table 5.1; alternatively, see Appendix H.)

The validity and practicality tables are based on validity and practicality data, respectively. In contrast, the items in the impact potential table are *indicators* that the desired characteristics were achieved. Hence, the impact potential table shows how findings (from validity or practicality related data) contributed to improvement of the program and overall participant assessment of those aspects (from impact potential data).

	Validity	
	State of the art knowledge	**Internally consistent**
Content	*Curriculum design and development knowledge; related professional development knowledge*	*Ideas in various components are in line with those in other areas*
	Participants evaluating the first prototype (13) recommended the use of concept mapping to help users organize their thoughts on lesson content. This suggestion led to an agreement with the producers of Mindman© to distribute their program with CASCADE-SEA; and to the inclusion of sample concept maps for each topic covered within the program.	During early stages of gathering design ideas (3) and through later versions of product development (17, 19) participants emphasized that the link between the components (and related consequences) not only needed to exist, but should be transparent to users. Toward illustrating how rationale ideas relate to other parts of the program, Kasey's third button ("Tell me the link with my rationale?") was designed to speak to this need.
Support	*Advice on materials design; Guidance on embedding materials in professional development*	*Tips, guidelines, templates, advice and help functions are perpetually offered in a consistent fashion*
	Participants evaluating both the first and the second prototypes (13, 14) offered suggestions on how to help users improve the quality of their lessons. Such ideas shaped both the overt support offered (e.g. choice menus) in the lesson builder as well as the implicit support given through the structure of the lesson template (summary, preparation, lesson body, conclusion, teacher notes).	Participants recommended (17) that each main phase in the program produce some kind of tangible output that records user decisions, reflects them in another form and offers opportunity for changes, updates or tailoring. Each main component in CASCADE-SEA now features such documents (rationale profile, analysis plan, lesson plans and evaluation plan) as well as guidelines on how and why to customize them.
Interface	*Maximizes the potential of modern ICT facilities*	*Functions as intended, regularly*
	Participants involved in evaluation of prototype two (14) suggested that the database connection be used in other areas of the program, not just for the lesson body. This prompted a complete revision of the 'Idea Book' and the 'Clip Art Gallery' such that they were integrated in a broader database that also contained vocabulary words (and editable definitions) and complete lesson plans. Further, this database was made accessible from the toolbox as well as the design area of the program.	Participants evaluating the third prototype (19) expressed frustrations with data loss. In some cases, this was due to power failures, and in other instances this was because users did not save their work. To relieve the user of this responsibility, an auto-save feature was built into CASCADE-SEA, so that the program automatically records new work in the program every 10 minutes, without any action on behalf of the user.

Table 5.2: Examples of (re)design decisions based on findings related to validity

	Practicality		
	Instrumentality	**Congruence**	**Cost**
Content	*Guides the user step-by-step in making materials; Offers freedom to work at own pace and in own style*	*Links up with the needs, wishes and context of the users*	*Content should include enough of what users need, and not bog them down with unnecessary steps*
	Participants suggested (22) that CASCADE-SEA allow the user to indicate when more (and less) support is needed by offering "I don't know" as possible responses to rationale questions. These options were built in, with the related consequence that CASCADE-SEA makes suggestions for what to do next (in analysis) based on user uncertainties. But these tips remain optional.	Participants emphasized early on (9) and during design activities (26, 27) the importance of incorporating local resources into lesson materials. The 'Idea Book' started out as a way to spur on user thinking in this area, and evolved into database contents such as improvisation of equipment and activities that rely on cheap and or local supplies.	Participants recommended (13, 30) that the user maintain the majority of control over what to do and how to do it. Rather than forcing any particular path, regular suggestions from CASCADE-SEA were preferred. (Re)design decisions based on this idea included the simplification of advice given to the user and its presentation (e.g. ✓,✓+ as described in Chapter 4).
Support	*Explains how to use program clearly and concisely*	*Support is relevant and usable*	*Support should be extensive, lowering the threshold of investment cost to the user*
	Some participants found the level of English used in the program to be challenging (24). One response to this finding was the creation of Kasey's second button, which offers clarification of difficult words in each area of the program.	During the analysis phase, participants identified (9) the most promising setting for the use of the proposed program: TRCs. Throughout design and development, attention has been given to maximizing the potential of a shared resource (e.g. by asynchronous sharing through the database and targeting small teams of designers, not individuals).	Participants especially appreciated the pre-made, editable samples that came along with CASCADE-SEA (30) and requested much more of the same type of support. As a result, 'canned' documents were incorporated into each main area of the program (along with recommendations on how to customize them).
Interface	*Buttons, navigation and functions are clear*	*Interface 'feels' nice and safe, users are not alienated but motivated to use the program; Operates on technology that is available in the target setting*	*Interface should reflect the flexibility of the system, in which users determine how they would like to go through the program*
	Participants criticized (17, 22, 25) the navigation options (particularly the main panel) in various prototypes. This was revised three times before feedback on the final version confirmed that this aspect was quite clear.	Toward making the program 'feel' more inviting, participants recommended the use of more colors and icons (26). These ideas helped shape the current interface design.	Participants appreciated the ease with which they could alter documents (31). To clarify and emphasize this feature and the program's flexibility (e.g. building lesson inside program with guidance or working independently with the template) additional instructions were added.

Table 5.3: Examples of (re)design decisions based on findings related to practicality

	Impact potential	
	Yields better quality materials	**Enhances the professional development of users**
Content	*The materials that are developed through use of CASCADE-SEA should be valid, practical and effective*	*CASCADE-SEA should help users to think about materials development in a (more) systematic and thorough fashion*
	Participants suggested (22, 31) that exhaustive use of examples would help users to understand and thereby improve their work. This suggestion was taken and many examples, samples and templates were incorporated into the program. Comments given (55) show that users found these elements valuable, as seen through their explanation of why materials made with CASCADE-SEA are of better quality than those made without the aid of the computer.	Participants offered suggestions (13, 15) pertaining to how CASCADE-SEA might be able to help users generate a clear vision on what they want to do (in terms of making materials) and why. These ideas were incorporated into the rationale component (e.g. by asking users to consider the difficulty level of the subject matter addressed as well as the target teacher's experience, and offering tips accordingly). Participant comments (39, 40) show that these attributes were appreciated and that the process of creating a rationale profile is a valuable learning experience.
Support	*The materials that are created with CASCADE-SEA should contain clear, useful procedural specifications*	*Teaches users where resources can be found (inside the program), and how they may be used and/or adapted for own setting*
	Suggestions were given as to how CASCADE-SEA can help the user build up a well-structured lesson plan, including step-by-step guidelines. For example, ideas were given (32) as to how CASCADE-SEA could remind the user (of the program) to remind the teacher (using the materials made with this program) to consider ways in which that lesson relates to everyday life. These (and similar) ideas were embedded in the system, and are cited by participants (36, 37) as contributing to more clearly structured lesson plans.	Early on, participants emphasized the importance of offering subject-specific support (2). In order to provide tailor-made support without the associated risks of rigidity, the CASCADE-SEA program offers generic guidelines, illustrated through subject-specific examples (e.g. sample lesson series goals, concept map templates). Participants found this balance to be a useful start, although the addition of even more (subject-specific) examples was encouraged (56, 58).
Interface	*The materials that are generated with CASCADE-SEA should evidence attention given to form and style*	*Interface helps (teams of) users to visualize the process of materials development and make their work more transparent*
	Participants gave suggestions on how to improve different aspects of the layout of the materials generated with CASCADE-SEA (13, 15) such as, a separate area for 'Teacher Notes' (14). These ideas were implemented in the system, and were valued by participants who later commented (54) on the visual clarity of the materials. It was further observed that, even when encouraged to make any desired changes, most participants maintained the general form and style as generated by CASCADE-SEA.	Participants suggested that CASCADE-SEA can contribute to user thinking by both explicit prompts (such as posing salient questions [13]) and implicit structuring of tasks (as seen through the procedural and conceptual map offered in the main menu page [3]). These types of cues were appreciated by participants (38) who said that the structure helped their work to be more systematic, and that the program reminded teachers of responsibilities which might not ordinarily be considered.

Table 5.4: Examples of (re)design decisions based on findings related to impact potential

The examples of (re)design decisions presented on the previous three pages offer insight into the way(s) in which the research findings contributed to the development of the CASCADE-SEA program, and the evolution of the underlying design ideas. As mentioned earlier (in Chapter 3 and in this chapter), much of the data collected pertained to more than one quality aspect simultaneously. The examples given in Table 5.4 related to the impact indicators show how decisions about the program's validity and practicality influenced its impact potential. Additional discussion along the theme of the interaction between quality aspects is presented in Chapter 6, as well as other reflections on the study as a whole.

Chapter 6

Discussion

The CASCADE-SEA study was initiated to explore the potential of computer supported curriculum development within the context of secondary level science and mathematics education in southern Africa. Through the iterative process of analysis, prototype design and evaluation, insights were sought with regard to the characteristics of a valid and practical tool that possesses the potential to impact the performance of its users. Whereas previous chapters in this book have examined the road taken to obtain such information, this chapter reflects on the implications of the journey as a whole. It begins with a brief review of the activities that took place, followed by an examination of the principal findings. Thereafter, reflections are presented on the questions asked, the methods used to answer them and the results obtained. Based on this discussion, conclusions are drawn with regard to the main aim of the study. This chapter closes with recommendations for future endeavors in terms of both products (computer supported curriculum development tools) and processes (development research) of this nature.

6.1 Summary

6.1.1 Research question and approach

The CASCADE-SEA study originated as offspring from the union of three trends: the international growth of ICT in general and EPSS in particular; the University of Twente's commitment to exploring the field of computer supported curriculum development; and increased collaboration with science and mathematics curriculum development programs in southern Africa. It was based on the notion that curriculum development and teacher professional development are two processes that occur simultaneously, particularly at the crossroads of exemplary lesson materials creation. As described in Chapter 1, the aim of the study was to explore how the computer might be able to contribute to and even enhance the synergy that exists between curriculum development and teacher professional development.

At the beginning of the study and throughout its evolution, guidance was sought from literature relating to curriculum development, teacher professional development, exemplary materials, existing support structures (such as TRCs) and computer-based performance support. Insights (such as those described in Chapter 2) from relevant literature along these thematic lines helped to shape the structure of the study as well as the CASCADE-SEA program itself. These insights were articulated in the form of tenets that served to guide research and development activities. Central to these tenets are the following topics: local relevance, collaboration, authenticity, mutual benefit and continuous (re)analysis.

Because of its natural 'fit' with the foundational tenets, a development research approach was selected to answer the following main research question:

> *What are the characteristics of a valid and practical support tool that has the potential to impact the performance of (resource) teachers in the creation of exemplary lesson materials for secondary level science and mathematics education in southern Africa?*

As outlined in Chapter 3, the research featured three main phases: needs and context analysis; design, development and formative evaluation of prototypes; and a semi-summative evaluation. Each phase consisted of multiple cycles of research activities; and each cycle contained various circuits, involving different groups of (expert and user) participants through different types of strategies. In total, research activities were conducted through 34 circuits involving approximately 510 participants from 15 countries. Participant data were collected throughout the circuit activities through 108 instruments of the following types: interview and walkthrough schemes; questionnaires; discussion guides; observation and demonstration schemes; logbooks; and document analysis checklists.

Both the data collected during the various cycles of the study and the products generated are viewed as research outcomes. In addition to the program itself, the articulation of product characteristics for the CASCADE-SEA support tool was sought. These characteristics eventually took shape in three layers of abstraction. The *foundational tenets* were most abstract, highlighting implications of the aforementioned topics with reference to program design. The *development guidelines* featured criteria pertaining to the content, support and interface of the to-be-designed program based on literature as well as experience and reflection. The most concrete layer was the *product specifications*, which represented developer ideas on how to achieve the characteristics prescribed (by the foundational tenets and the development guidelines) for the content, support and interface of the program. Together with this platform of ideas (which emerged and took shape throughout the study), the CASCADE-SEA support tool evolved through four prototypes and final version (please see Chapter 4 for additional information). This evolution was informed through the data collected via the aforementioned circuit activities.

The previous chapter discussed the results of the research activities that contributed to the CASCADE-SEA expedition. It concluded with a discussion of how data contributed to program development. The following section summarizes the overall results from this exploration with regard to program quality.

6.1.2 Findings concerning overall program quality

The participant reactions presented in Chapter 5 (especially those from latter evaluations in the design phase and the semi-summative evaluation phase) showed that CASCADE-SEA does meet the criteria of validity, practicality and impact potential, but not without certain caveats. These findings are summarized below. (To locate the relevant data, the numbers in parentheses correspond to Table 5.1 and the section headers from Chapter 5.)

Validity
As described in Chapter 3, validity pertains to state-of-the-art knowledge (about curriculum development, teacher professional development, computer-based support and how to realize it via the interface), and internal consistency (coherence throughout the various system components). Few participants disputed CASCADE-SEA's possession of state-of-the-art knowledge; and similarly, sparse commentary was given concerning internal inconsistencies. In fact, numerous participants were enthusiastic about these aspects of the program. However, the *degree* to which the program may be labeled valid is much more difficult to pinpoint.

For example, while participants generally agreed that CASCADE-SEA contains state-of-the-art knowledge, some found the volume to be overwhelming, some were satisfied with it and still others considered it (present but) incomplete (14, 15, 16, 42, 43). Participant opinions also varied, though not as emphatically, in terms of the internal consistency of the program. Whereas most participants were satisfied with this aspect in relation to the interface and support, opinions diverged with respect to the content of the program. Some participants appreciated the inter-connectedness of the content in the various components, but the majority found this aspect to be (present yet) weak (44, 45). Although determining where CASCADE-SEA's validity should be placed on a quality continuum remains difficult, the participant reactions indicate that the support and interface are subject to less dispute than the content of the program.

Practicality
Practicality refers to the way in which CASCADE-SEA fits with contextual realities as well as the individual perceptions and/or beliefs of users in the target setting. This includes the notions of instrumentality (specifying procedures to complete a task); congruence (in this case, linking with the way teachers go about producing exemplary lesson materials in the target setting); and cost (the amount of investment effort compared to the return yielded). Generally speaking, the program was viewed to be practical, and based on the participant responses, 'quite practical' might be a better descriptor. Here too, the main area in which opinions diverged was in relation to the content.

With regard to instrumentality, participants generally appreciated the guidance offered by the program, although some concern was expressed (mostly by experts in curriculum development and teacher professional development) that CASCADE-SEA could offer too much step-by-step guidance (22, 23, 24, 25, 47, 48). To some user groups, the level of English used was seen to present an overly difficult challenge. Most participants felt that the program was quite congruent with the needs and wishes of the target group, and many emphasized the importance of using the program within a training setting (27, 28, 29, 49, 50). Opinions were more mixed with regard to the costs associated with using the program, in particular: time investment. Whereas some participants found CASCADE-SEA to shorten the length of time they would otherwise invest, others found the opposite to be true, mostly because the program inspired them to be more thorough than otherwise would be the case (31, 32, 33, 51, 52). Although suggestions were given for improvements, participants were more consistently satisfied with the support and the interface aspects of the program. And even though their reactions were not always unanimous concerning the degree to which CASCADE-SEA may be labeled practical, the overall consensus was far less varied when compared to validity aspects.

Impact potential
In the case of CASCADE-SEA, positively impacting the performance of its users means that it helps to create better quality materials than those that would be made without the support of the computer. In addition, the program should contribute to the professional development of its users. The data collected throughout this study indicate that CASCADE-SEA does, indeed, possess the potential to positively impact the performance of its users, but that the extent of this potential is strongly influenced by how the system is used and by personal characteristics of those using it.

The structured nature of the program was judged by participants as useful in helping them articulate procedural specifications for the teachers who eventually use the materials (35, 36, 37, 54, 55). The support and layout of the materials created with the aid of CASCADE-SEA were judged to be easy to use and comparable to or better than those created without the aid of the program. Further, participants generally indicated that they felt they learned from the CASCADE-SEA experience, although some (mostly experts as well as a few user groups) raised concerns that the program could make things 'too easy' for the user and either stifle creativity or encourage 'laziness' as a result (38, 39, 40, 56, 57). Most participants noted that such concerns (as well as the potential benefits) would be influenced by contextual factors affecting implementation.

6.2 Reflections

In order to draw conclusions based on this study, it is worthwhile to re-examine the research as a whole with the added perspective of hindsight. Toward that end, this section revisits the main research question, the way it was answered and the chief findings.

6.2.1 Reflections on the research question

The CASCADE-SEA study sought to answer a research question with three main elements by looking for the *characteristics* of a good *quality* program for use in a particular *context*. This section decomposes the inquiry, in a critical reflection on the focal points of this study. Here, the goal is quite transparent: to question the questions.

Program Characteristics
Originally, this study sought to articulate program characteristics relating to the CASCADE-SEA system's content, support and interface (including technical aspects). As efforts evolved, these distinctions eventually needed to be further decomposed, because the degree of variation among them proved too great to serve the purpose of discussion. Hence, (as described in Chapter 4) the three types of characteristics were depicted in three layers of abstraction: tenets, guidelines and specifications. Whereas the tenets related more to the philosophical inputs for the system's design, the guidelines verbalized the theoretical contributions to the CASCADE-SEA program. Yet, such characteristics are not only derived from consideration of *what* a system should do (and, to some extent, *why* it should do that). The way these characteristics are realized in practice is of paramount importance, especially because the leap from intentions to implementation (a well-known area of difficulty in most innovations) remains surprisingly far more difficult than (often) anticipated. For this reason, product specifications, explicitly stating *how* the program should be sculpted to achieve the desired characteristics, were considered essential.

These three layers are also reflected in Van den Akker's (1999, in press) description of the kinds of heuristics that should be the result of development research activities. He recommends the following 'mapping sentence' for design principles: "If you want to design curriculum X (for the purpose/function Y in context Z), then you are best advised to give that curriculum the characteristics C_1, C_2 ...C_n (substantive emphasis), and to do that via procedures P_1, P_2 ...P_n (procedural emphasis), because of (theoretical/empirical) arguments A_1, A_2 ...A_n." As discussed in Chapter 4, these (substantive, procedural and theoretical/empirical) ideas often emerged, or became better articulated, as a result of the design, development and evaluation activities themselves. In this sense, the iterative process of prototyping contributed not only to sharpening the answers to the main question, but to fine-tuning (aspects of) the question itself (i.e. decomposing the notion of characteristics even further). The same holds true for the quality criteria, discussed below.

Quality Criteria

As discussed in Chapter 5, much of the data collected related to more than one quality aspect (validity, practicality and impact potential) simultaneously. However, during analysis, data were classified according to only one area. A number of merits and faults may be associated with the decision to try to sharpen distinctions that are, naturally, more blurred.

As with the program characteristics, decomposition of the notion of quality was seen as a route to being able to articulate its essence. Then, when subaspects were combined with the (content, support and interface) program characteristics, they helped to shape an image of the desired system (as indicated in Table 3.1). Further, this helped in terms of understanding the data collected. Redundancies were reduced by sorting data based on the most - but not the only - relevant relationship to the quality criteria. This, in turn, helped to clarify and highlight emergent patterns. In this sense, the quality criteria served their purpose.

But reflection on the findings shows that they might have served it too well. That is, careful study of how those desired aspects would actually take shape revealed that, in a few ways, they were in competition with each other. At the very least, the logic behind some of their definitions turned out to be circular. Take, for example, the characteristic of program content. When it comes to making decisions about the curriculum design and development knowledge that should be included in CASCADE-SEA, a number of aims are pitted against each other:

- Toward *state-of-the-art knowledge* (validity), curriculum design and development knowledge should be included, but the question of how much (state-of-the-art knowledge) is left over to practicality, which says:

- Toward optimizing user *cost* (practicality), the program should include enough of what the users need and not bog them down with unnecessary steps, but:
- Toward supporting *professional development* (impact potential), the program should help users to think about materials development in a (more) systematic and thorough fashion.

Depending on the user's perspective, offering 'room to grow' inside the program could alternatively be experienced as 'too much unnecessary information.'

It would appear that conflicts such as these are inherent in the structure of the quality aspects, as they were defined in this study. However, it would be unfair to say that the ramifications of their friction were thoroughly understood at the time the study (and in particular, the main research question) was conceived. As these implications emerged, they served as perpetual reminders to weigh available options and insights carefully before making the unavoidable trade-off decisions.

As noted in section 6.1, determining the validity, practicality and impact potential of CASCADE-SEA was not as tidy as trying to answer a yes/no question. Understanding the program's quality really pertains less to a black or white issue and more to assessing where, on a grey scale, the program should be located. But as this discussion has revealed, such a location is in flux, depending on which quality aspects are being inspected, and which ones are given priority. Moreover, these issues are dependent on *who* is looking to carry out *what task(s)* under which *circumstances*. As a result, these are reflections of personal value judgements, more than indications of any objective facts. During evaluation activities, participants gave their opinions on the differing quality criteria separately (for example, they rarely reflected on validity issues influencing practicality ones) and - as one would expect - they usually did so against the backdrop of their own, individual, needs, interests etc. Similarly, researcher/developer decision-making was colored by certain influences. Specifically (as mentioned in Chapter 5), the overarching aim ("design curriculum X [for the purpose/function Y in context Z]") served as the ultimate trump card in trade-off decision making, as addressed below.

Target context

In order to design a good quality system for a particular setting, a working knowledge of that setting is needed, as well as an understanding of what good quality (for that situation) is. The previous section examined the quality aspects in general, and this section continues the discussion with a look at contextual factors that influenced trade-off decisions. For each program characteristic (content, support and interface) judgments had to be made when it came to prioritizing state-of-the-art (a validity issue) vs. state of practice in the target context (a practicality issue).

For example, in terms of program content, CASCADE-SEA does not (as some participants noted) explicitly address constructivism (which could easily be made a priority from the perspective of validity). But, some experts argue that radical constructivism (in the short term) can actually do a disservice to African education (Taylor, 2000). They cite a combination of factors to be the cause, such as: disputed ramifications and benefits of this approach; debate on how to implement it (methods); and its reliance on a well-educated teaching force (cf. Sanders, 1999). The choice to build CASCADE-SEA as a teaching and learning methods 'agnostic' was predicated on the supposition that it should speak to the highly varied needs of the majority, not the specialized needs or preferences of the few. And, no matter how brilliant an idea is, it can mean nothing in practice if not examined for its appropriateness vis à vis the existing situation. In the words of Lewin (1985, p. 122):

> *We can conclude … that attempts to improve curricular quality depend on realistic initial appraisals of goals and need to start from understanding of what is, not what ought to be, the reality of classroom practice … Moreover, due attention must continue to be given to the improvement of existing curricular quality despite the attractions of novelty and project styles of innovation which focus on small areas of need. The problem in many countries is that existing curricular intentions are not adequately implemented, and that change may exacerbate this by imposing additional demands on hard pressed teachers and distract attention from impoverished quality in the system as a whole.*

In addition to influencing program content, contextual factors also shaped the way support was designed inside the system. In particular, it was designed for integration into a professional development program, not to be used in isolation. For example, a number of participants lamented the fact that CASCADE-SEA allowed users "too much freedom," and others were concerned that the computer had "too much control" over the materials development process. In terms of being able to make a valuable contribution to the professional development, CASCADE-SEA supports users during curriculum development processes *not* through prescription, but by stimulating deliberate consideration. Hence, support offered *inside* the tool spurred on group introspection; and this is done in such a way as to support user and implementer choices for reflection *outside* the system. Opting for a program that relies on the local insights of those using it (as opposed to a self-guided application) was based on a belief that this would, ultimately, be more appropriate and effective, particularly in light of the target context. Given that participant perceptions are an influential ingredient in program impact (Guskey, 2000), such an approach seemed to be the worthwhile, as it not only allowed for tailor-made use (i.e. integration into existing frameworks), but it stimulated (would be) users to consider how to maximize the potential benefits of the program within their own settings.

In terms of the program's interface and technical complexion, numerous clashes (between state of the art and state of practice) are obvious, given the fact that technological infrastructure is notoriously weak in developing countries. For example, the poor or out-dated facilities available at many resource centers provided a sound argument for building a technically 'lite' version of CASCADE-SEA. On the other hand, the realization that the final version of the program was to be ready a full four years after the research was initiated provided an argument to consider state-of-the-art now vs. anticipated state of practice (in four years). This allowed for more (technically) demanding aspects to be included than otherwise might have been advisable. Still, certain options (such as an Internet-dependent version, as opposed to the resulting Internet-supplemented one) were ruled out because of contextual constraints. But even in settings where infrastructure is not a barrier, experts have found that, when it comes to EPSSs, what is in the realm of possibilities may not be feasible in practice (Miller, 1997). In terms of the interface and technical aspects of CASCADE-SEA, various types of factors (infrastructure, know-how, etc.) within the target context instigated continuous 'Can it be done? … Should it be done?' deliberation during design and development activities.

In this study, some elements of practicality actually turned out to be prerequisites to determining (aspects of) validity. For example, decision-making regarding state-of-the-art curriculum development knowledge (a validity issue) to be integrated into the system was strongly influenced by understanding of target user perceptions and habits (a practicality issue). This is contrary to the assumption made at the beginning of the research (that practicality could best be studied after validity issues were clarified) and the resulting shift in emphasis (from validity to practicality to impact potential) during data collection activities. Fortunately, however, the methods used allowed for compensation in this area, as the integrated nature of prototypes (and the evaluation thereof) emphasized assessment of the system as a whole. In fact, because validity and practicality were assessed simultaneously, this process highlighted areas of discord by bringing any (potential) conflicts between them to the forefront of discussions. The following section further examines this and other insights pertaining to the methods used.

6.2.2 Reflections on the research approach

A development research approach was used throughout this study because of the opportunities it offers in terms of devoting attention to the uncertainties and complexities of educational realities. While the overall benefits of this approach are perceived to have outweighed the risks, thoughtful contemplation of the execution of this study would not be complete without discussing the enduring struggle between the challenges and opportunities presented by this approach. Three main points are addressed in this regard: multiple roles played by the main researcher; dilemmas associated with authentic research settings and the emergent (adaptive) design of the study.

Many hats

Section 3.5 addressed the notion that this study was both threatened and enriched by the 'many hats' worn by the main researcher, who was (simultaneously) also the designer, developer, programmer, and (in most cases) implementer as well as evaluator of the CASCADE-SEA program. Whereas earlier discussion of this topic examined associated risks and measures taken to mitigate them, this section discusses decisions made to maximize the potential benefits of this situation. Wearing many 'hats' was the result of a conscious decision, based primarily on the perceived benefits of shortening the lines of communication (between hats) as much as possible. However, this highly efficient means renders interactions so intimate, that the risk of blurring roles (already challenging when undertaken by separate individuals) becomes even greater, as the communication takes place all in one mind.

“Rather than pretending to be objective observers, we must be careful to consider our role in influencing and shaping the phenomena we study. This issue is obvious when individuals take on multiple roles of researchers, teachers, teachers of teachers…” (Putnam & Borko, 2000, p. 13). Acknowledging the inevitable impact of researchers (and multiple hat-wearers in particular) on the context in which understanding is sought is a first step toward combating associated obstacles, such as (cf. Krathwohl, 1993): the Hawthorne effect (involvement in the study makes participants feel special and thereby influences their behavior); hypothesis guessing (participants try to guess what the researcher seeks and react accordingly); and diffusion (knowledge of the treatment influences other participants). Thereafter, these threats may be further reduced by striving for unobtrusiveness through making the research setting as natural and as genuine as possible. In the case of the CASCADE-SEA study, this was done by seeking out ways to integrate research activities in (parts of) existing participant routines. Doing so also affords additional opportunities, such as gaining a deeper understanding of the context.

Other decisions made during the study helped to maximize the potential benefits of multiple roles. For example, the selection of a friendly, easy-to-learn environment for developing the software allowed for truly rapid prototyping to take place, both in the researcher's mind and electronically. The front-end investment in training the researcher to use Macromedia's Authorware™ programming environment paid off in various ways. One of the most substantial contributions this decision yielded pertains to problem solving in designing the CASCADE-SEA program. Generally speaking, a software developer is acutely more aware of technical options available than the typical educational designer, so much so in fact, that a great deal of their tacit knowledge often remains inaccessible to other members of a development team. This was certainly the case at the start of the CASCADE-SEA endeavor. Nevertheless, by schooling the researcher/designer in how (and why) certain technical aspects are structured, ideas for support were approached creatively, from the various perspectives. Further, these ideas were able to evolve more quickly and appropriately by actually creating, testing and revising them immediately, with the input of the multiple hats.

Although eventually optimized for Windows 95, the multi-platform functionality of development within Authorware allowed the (substantial) operating system decision to be postponed until well into the development process. In addition to explicit analysis of the context in this regard, multi-platform development reduced the risk of building software that runs on an operating system which is not (sufficiently) available in the target setting. Throughout the first half of prototype evolution, creating separate versions of CASCADE-SEA for Windows 95, Windows 3.11 and Macintosh systems was quick and easy. Additionally, through Macromedia's Shockwave™ technology, the option of creating an Internet-based version (from the Authorware script) remained open for consideration. (Even now, these options are available, but with the revision of database connectivity in prototype three, the processes involved in platform translation have become more substantial.)

Real-world research settings bring real-world complications
The research approach used in the CASCADE-SEA study has allowed data collection activities to take place in cooperation with naturally-occurring test beds. The benefits of conducting (parts of) the study in authentic settings would seem obvious: the more genuine the research situation, the more genuine the research results will be. To be sure, these benefits outweigh the risks when it comes to investigations such as this one. However, deeper understandings come at the (potential) cost of losing control over data collection rigor. When researcher interests are no longer the only ones at stake, compromise is imminent.

For example, participants in earlier circuits learned about the CASCADE-SEA program, and raised the issue of exploring the potential role of this program in preservice education. Adding preservice teachers (and associated counterparts) to the sample group resulted in the collection of hereunto-unforeseen (types of) information that turned out to be quite useful. However 'population validity' (cf. Bracht & Glass, 1968) was consequently threatened. Given the fact that generalization to a particular population or situation was not a high priority, and that deeper contextual understanding was considered more valuable, this seemed an acceptable concession. Nonetheless, it does typify the kinds of dilemmas faced by those who prioritize the mutual benefit of research activities (for researchers and participants). At the same time, it emphasizes the need for researcher-participant creativity in the selection of activities that meet the needs of all parties involved.

In addition, real-world investigation settings also set certain limitations. Particularly when a 'cultural stranger' (cf. Choksi & Dyer, 1997 in Thijs, 1999) attempts to carry out research in a foreign setting (as was the case with most circuits of data collection activity), the degree to which an 'outsider' can conduct meaningful research must be addressed. In many situations, participants are sometimes hesitant to be completely open with researchers from different cultural contexts. Toward earning participant trust and building an understanding of the context, the importance of collaboration and mutually beneficial activities cannot be over-emphasized, as these are the two main avenues available to a researcher who prioritizes the 'insider' perspective. This is not to say that being an outsider is completely without advantages. In some situations, it actually allows for a degree of objectivity and, along with that, a freedom (or forgiveness) for honesty that is not permitted to those within a particular group.

Adaptability

In addition to the advantages mentioned earlier, donning multiple hats simultaneously also contributed to this study by facilitating 'on-the-fly' planning which, given the aforementioned real-world research settings, was invaluable. Decisions regarding research and development activities could be weighed, made and changed more easily at any given moment, because (most of) the relevant perspectives could be consulted. Here, too, the use of the Authorware environment proved valuable. The structure of the program's flowline forces the user to work in (nested) branches. As a result, pieces of the program may be altered without forcing major updates in other parts of the system; but when desired, program-wide changes are also relatively easy to integrate. This allowed a great deal of flexibility in terms of prototype development, as sub-components of the system could be moved and swapped in and out of other areas. Because of this, decision-making in terms of prototype planning could afford to be more influenced by other research-related factors than by any technical considerations.

Further, the flexibility provided by multiple perspectives allowed fortuitous data collection opportunities to be utilized. Even though the structure of data collection activities were subject (if not open) to local influences, the basic pattern of exploring validity, practicality and impact potential (in - roughly - that sequence) remained the same. Not only was this adaptability valuable because of the additional data that were collected, it also proved insightful in terms of learning about what additional (kinds of) data collection opportunities can be useful. For example, researcher expectations regarding the salience and intensity of some data collection activities were quite low, especially in such non-committal settings as brief (half-day) demonstration/discussions. But by having the flexibility to 'give it a try' some of these activities turned out to be much more useful than anticipated. Although rarely sufficient to stand alone (without the input of longer-term, hands-on participant experience), data collected in these sessions often served a confirmative purpose (highlighting emerging patterns in the findings). Similarly, these types of sessions often informed one perspective (hat) better than another. And finally, because priority was given to the quality of the feedback (as opposed to the quantity), even brief sessions allowed particularly insightful individuals to share their ideas.

Circuit 26 was notably illustrative in this regard. It was entirely unplanned (it took place while the researcher was on holiday in Namibia) and seemed, at the start, to have more potential toward public relations than toward the collection of useful data. However, the discussion that took place during that two-hour seminar turned out to be one of the deepest, most insightful sessions in the entire study. While it yielded relatively little data in terms of detailed prototype feedback (making this circuit less relevant for the evaluator hat), this circuit contributed significantly to the evolving conceptualization of what the program should (and should not) aim to do and why, thus being quite relevant for the developer hat.

Looking at the research activities overall, it would seem that the essence of those processes that were so central to this study boil down to one main idea: adaptability. Within the framework of a systematic approach, this study incorporated the necessary and sufficient conditions for enabling the reflective processes that fed its evolution. Figure 6.1 presents a model that reconstructs the development research approach used within the CASCADE-SEA study and aims to portray its most salient characteristics.

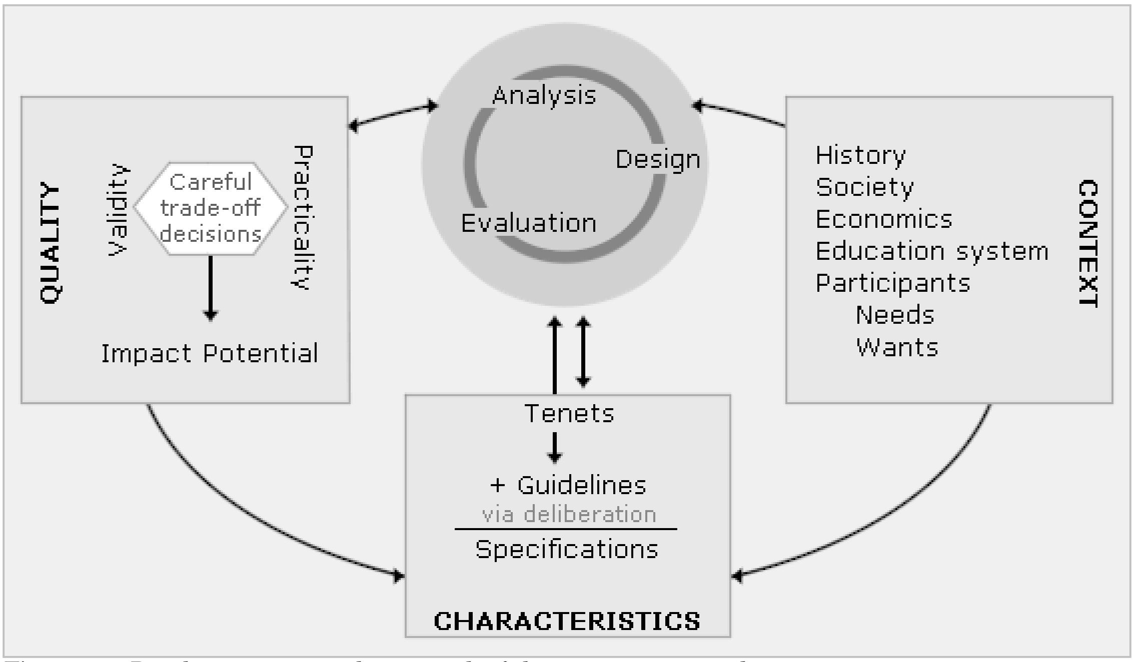

Figure 6.1: Development research approach of the CASCADE-SEA study

This model depicts the main development cycle (analysis, design and evaluation) that provided the vehicle for this research. At the same time, it illustrates a number of processes taking place in this study, namely:

- Foundational tenets evolved through research and development activities and vice versa.
- Insights about the context, desired quality aspects and program characteristics served as main areas of input to the (combined) research and development processes.
- Research and development activities facilitated (re)conceptualization of program quality and characteristics.
- Being a design study (and not an implementation study), research and development activities had no substantial impact on the context.
- Contextual factors influenced program characteristics directly (especially by helping to shape the foundational tenets).
- Quality aspects evolved through careful trade-off decisions which were directly informed by research and development activities and indirectly influenced by design principles (characteristics) resulting from prototyping activities.

As thoughts matured in one area, these influenced ideas in others, and so on. The development research approach used throughout this study has offered many possibilities for understanding and dealing with the myriad complexities inherent to the nature of the CASCADE-SEA investigation. At the same time, additional challenges have been brought along with it. Challenges in terms of data collection also imply challenges in terms of data interpretation, as discussed in the following section.

6.2.3 Reflections on the findings

Compared to the relative consensus on support and interface issues, participant opinions were especially mixed in terms of the quality of the CASCADE-SEA program's content (it offered too much for some, too little for others). In the light of the known complexities of the realities in which data were collected, this section discusses possible explanations for such disparate findings. Two issues bear particular mention: user perspectives and participant preconceptions.

User perspectives

Beauty, they say, is in the eye of the beholder. The evolutionary, collaborative nature of this study resulted in various types of beholders commenting on the CASCADE-SEA program - more than originally intended. One likely reason as to why participant opinions (especially in terms of the validity of program content) varied so much is because their own needs, wishes and preferences are also so diverse. Especially since participants extended beyond the intended target user group (as was the case with preservice teachers and lecturers), this study invited reactions based on participants' own ideas regarding (alternative) applications for the program.

For example, the content of the CASCADE-SEA program was judged by some participants to be (at times too) comprehensive and by others to be deficient. Related to this, such variation in opinions often sparked discussions about the merits of two versions of the program, best characterized as: CASCADE-PRO (comprehensive) and CASCADE-LITE (simple). Generally speaking, it was found that those who argued for a simpler version of the program were more interested in (curriculum development) task support per se, than they were in the other main aim of the program: fostering the professional development of its users.

It was often these same individuals (a mixture of experts and users) who pointed out that tools such as this one are not appropriate for 'regular' teachers. This confirmed the assumption made by the researcher that such a tool does not fit with the needs, nor the daily practice, of secondary level science and mathematics teachers in southern Africa. While some argued that a LITE version of the program might be more suitable, others disagreed, echoing the sentiments of Eisner (1994, p. 127) who said that “curriculum development done by teachers can and often does take form in the creation of materials, but that curriculum development [by teachers] more frequently yields no materials but, rather, plans that might be no more sketchy than notes.”

In contrast, those who saw applications for this tool within professional development programs generally tended to appreciate the various components of the program as offering users room to grow. To this group, fostering insights into curricular processes through the structured analysis and evaluation of existing and nascent syllabi and materials (as advocated by Ben-Peretz, 1990) was a worthy pursuit. However, even some of those who valued the content of the program for its "systematic, rich, clear, thought-provoking" and "logical" nature identified concerns about cramping the user's style, dampening creativity or even encouraging laziness.

Interestingly, those individuals closely associated with the actual implementation of teacher professional development programs (particularly pre-service teacher educators) were less bothered by such concerns and much quicker to articulate their own preferences in terms of how they would use the system. This group seemed to view CASCADE-SEA as a source of ‘curricular possibilities’ and a basis for choice and action, as opposed to a vain attempt to render the development process 'teacher proof' (cf. Ben-Peretz, 1990; Clandinin & Connelly, 1992). Such ideas are closely connected with the basic notions upon which this study was founded. They also say something about the way in which this program should be implemented; namely, the use of CASCADE-SEA must be undertaken by (groups of) individuals who are confident and competent in ensuring that the program be used in such a way as to serve the purposes of *their own* ongoing endeavors.

Participant preconceptions

In addition to participant backgrounds and interests, another factor influencing beholder perspectives pertains to their expectations. A surprising number of participants seemed to expect the CASCADE-SEA program to generate automatic, immediate and complete results (in the form of materials) for them. At the same time, they anticipated this would happen without expending any effort and without relinquishing any control over the process. Despite the fact that such an attitude contends with some of the basic ideas behind the development of the system, it also evidences a certain degree of naiveté about the potentials of ICT and the processes associated with human-computer interaction.

Another pre-conceived notion that was frequently encountered contrasts with the aforementioned tendency of certain user groups to consider their own preferences and approaches to using CASCADE-SEA. Specifically, expert participant groups seemed to want to give the computer a greater degree of authority than user participant groups. While they were clearly more critical of the program (especially concerning the validity of the content), this group showed a predisposition to the assumption that the computer was supposed to offer all the ('right') answers, as opposed to helping users identify the best solutions for their own situations.

Finally, the fact that one area (content) stands out in contrast to others (support, interface) as being subject to such varied reactions, gives one pause to consider what, if anything, is unique about this aspect. Participants' preconceived notions about curriculum design and development knowledge (as opposed to support or interface knowledge) may have played a role. Because of their professional orientation (and related expertise), coupled with the fact that most (substantive, technical-professional and socio-political) aspects of curriculum are value-laden, participants were probably more adept at critically assessing CASCADE-SEA's content than the other aspects of the program. Consequently, the (relative) lack of criticism regarding support and interface aspects could stem from (comparative) inabilities to do so, together with an overabundance of content critique. On the other hand, explicit efforts were made to shape data collection activities in such a way that all participants could provide fruitful (critical, discriminatory) feedback.

6.2.4 Conclusions

The CASCADE-SEA study was designed to explore the potential of the computer to support science (and mathematics) education materials developers in southern Africa. Specifically, insights were sought into ways to effect the synergy between curriculum development and teacher development at a natural crossroads: the creation of exemplary lesson materials. Toward this end, research was conducted via the iterative process of analysis, design and evaluation concerning computer-based prototypes.

Through the development of a (satisfactorily, not perfectly) valid and practical system, this study has shown that the computer does have the potential to positively impact curriculum development and teacher development by supporting the creation of exemplary lesson materials in the aforementioned context. Users (generally) produce better materials than they otherwise would, and learn from this process due to the program's combination of:

- *Content:* CASCADE-SEA systematically structures the materials development process and illustrates its iterative nature through analysis, design and evaluation activities that are guided by an explicit rationale.
- *Support:* CASCADE-SEA blends generic and tailor-made advice; internal and external tools; implicit and explicit learning opportunities; and written and verbal communication aids to assist the user throughout the materials creation process.
- *Interface:* CASCADE-SEA offers the content and support through a direct, consistent and forgiving visual (and technical) representation, which grants the user both flexibility and control over the process.

Chapter 4 described the outputs of this research in terms of the characteristics of the CASCADE-SEA program, and Appendix G offers the tool itself. As discussed in the previous sections, these characteristics were presented in terms of content, support and interface and through three levels of abstraction (foundational tenets, development guidelines and product specifications). Together with the CASCADE-SEA program itself, these design principles speak to the main research question insofar as they illustrate the characteristics of a computer-based support tool for secondary level science and mathematics education in southern Africa that is both valid and practical with the potential to positively impact the performance of its users (as demonstrated via the data presented in Chapter 5).

Chapter 3 addressed the notion that this study was not so much structured to collect that information which would be considered *minimally necessary* to answer the research question, but to answer the question *as thoroughly as possible*. Toward that end, the reflections presented earlier in this section ascertained that the desired quality aspects are neither absolute nor completely objective. Rather, they are personal and relative to the context in which the program is used. In addition, the needs, expectations and beliefs of individual users shape perceptions about the program's validity, practicality and impact potential. Further, the user/facilitator agenda determines, in part, the way in which CASCADE-SEA is used. This, in turn, influences participants' perceptions about the program. Hence, the CASCADE-SEA research has also highlighted the importance of continuously seeking heightened contextual understanding as an integral part of the design and development process. Ideas on how to realize this have been presented throughout these chapters in terms of the specific path taken during this study. The following section applies these learnings toward suggestions for future activities.

6.3 Recommendations

The overall aim of much development research (and this investigation is no exception) is to learn about both that which is being developed, and the process through which it comes to fruition. Toward extracting insights from this study that could be useful to future endeavors, this section provides recommendations for continued exploration of computer supported curriculum development products (computer-based tools) and processes (development research).

6.3.1 The future of the CASCADE line of inquiry

In reflecting on the study as a whole, a number of ideas regarding the potentially useful ways to take this specific research further come to mind. Because many of those ways entail a broadening and/or a deepening of this line of inquiry, the SEA (Science Education in Africa) suffix may change, lose its emphasis or even disappear altogether. In this case, reference is made to a family of (potential) studies that share the CASCADE lineage. This section outlines recommendations for shaping further evolution of the CASCADE line of inquiry. After a brief review of the exploratory query findings, ways to improve existing components inside the system and viable routes for expansion are considered.

Potential applications beyond original intentions
As described in section 3.4.3, an exploratory query took place during the study's semi-summative evaluation phase. While this activity also contributed to an overall assessment of CASCADE-SEA's quality, the main aim was to explore potential uses for the program outside the realm of original intentions, by gathering useful and interesting ideas for future development from interested parties. Please refer to section 3.4.3 for information on how the query was conducted, to Appendix H (see summary

document: QUERY34) for the query data and to Appendix K for the query package itself (including the questionnaire used) and a synopsis of the findings. This section describes the main results from this activity, with regard to the future of the CASCADE family.

The query findings indicate that there is appeal for continuing this line of inquiry, though this comes as no great surprise given that the participants consisted of interested volunteers. However, the participant comments suggest certain directions that might be particularly worthy. Specifically, ideas were generated in terms of *who* the program should serve; *what* the program should contain; and *why* the program should be used. Based on these and related comments, additional ideas about *how* developments should take place were also generated.

According to the participants, a subsequent step in program development should consider testing or even implementation of the existing CASCADE software in a professional development program. During this (trial) implementation, participants suggested that CASCADE should be used as either a *tool* (for learning about computers or about curriculum development) or as an *example* (of how to go about materials development, or of computer supported curriculum development). Based on these experiences, future users/developers/researchers (from pre- and inservice programs as well as tertiary education programs) should consider their own wishes in terms of customization, pertaining especially to language and content. Depending on the groups involved and the (apparent) degree of enthusiasm, resources and relevance, decisions should then be made about how to go about realizing the desired alterations and strategies to support the full-scale implementation of a modified tool.

When the query results are compared to reactions of participants throughout the design and development of the CASCADE program, many of the same issues are brought to light, and a few new ones arise. Whereas the ideas of expanding the content covered and tailoring the language in which the program is written were raised earlier, the ideas of using the program in courses on interactive educational media or as a case example to inform development efforts were new. Although the query data offer no indication of the degree to which this program (or a version hereof) is appropriate for use in settings outside the (already rather broad) target context, it does suggest that alternative uses exist, that they are worth exploring, and that such exploration should be done in collaboration with the interested parties. Based on the aggregate conclusions of the main study and the exploratory query, the following section addresses recommendations for the future development of the CASCADE family.

Ideas for improvement of existing components

As discussed in section 6.2.4, participants found CASCADE-SEA to be satisfactorily valid and practical, but they also offered suggestions for improvements. While some recommendations pertained to refinements (e.g. language use), the majority concerned the deepening of existing elements. Toward elaboration and improvement, it could be quite useful to look around for compatible components already up and running in the software industry, rather than trying to 'reinvent the wheel.' Plugging into others' solutions (*if* they fit the need appropriately) can save time and thereby allow precious development resources to be spent on other aspects. Throughout this study, participants highlighted various areas within the CASCADE program that could benefit from elaboration, and often offered suggestions on how to do so.

Toward applying such ideas, future CASCADE versions might incorporate additional existing resources. During this study, four software companies and one publisher agreed to the open distribution of their materials. Given the goal of supporting educational improvement initiatives in developing countries, additional collaboration seems a likely possibility, for those organizations with a philanthropic history. And, especially for smaller institutions, the chance for developing mutually beneficial relationships exists. To illustrate, the following list offers four examples of ways to extend the functionality of existing components through (improving) connections with existing resources:

- *Assessment-building programs:* The addition of software to aid in the development of assessment strategies and materials could lend a much-needed boost to the assessment area of the CASCADE system.
- *Context-rich examples:* Partnering with other organizations that produce or manage lesson materials (or parts thereof) could allow for significantly more examples to be included along with the program.
- *Sample products:* Copious samples of products (e.g. polished up rationale profiles, customized evaluation plans, etc.) could be included with CASCADE so as to model the conceptual processes that should take place.
- *Enhanced database connectivity:* Integrating (as opposed to linking) CASCADE with a database would allow for additional opportunities to share and learn from good illustrations. This goes for the research-related phases (analysis and evaluation) as well as the design phase. For example, CASCADE already offers sample instruments to support the user in analysis and evaluation activities. But if it were linked to a database program in which the instruments were generated, two additional advantages would arise: (1) by selecting the desired fields within potential options, the program could generate tailor-made schemes (and provide the user with additional support during this process); and (2) by having the source items in the database, the system could also offer assistance in processing the data once it is collected.

Some other improvements of the existing program might benefit less from the tangible products of others and more from the theoretical ones. For example, building better, more intelligent support for designing lessons according to particular teaching/learning styles presents quite a challenge. Reigeluth (1999) tackled this challenge; and together with a classful of graduate students, created a 'Teacher Toolkit,' designed for this exact purpose (Reigeluth, 2000). Perhaps the insights from projects like this one (if not [parts of] the prototype itself) could be integrated into future versions of CASCADE, or other joint ventures.

Possible expansions

In addition to further exploration of how to optimize existing components in the CASCADE system, future activities should also explore promising new expansions. Participants in this study already recommended that other subject areas and other grade levels be addressed. Additionally, Internet options that were impractical at the start of the study might now be more accessible.

Jensen (2000) has been tracking Africa's Internet connectivity (and posting the information at Http://www3.sn.apc.org) since 1996. The following figures imply that re-examination of Internet options may be prudent, in light of future CASCADE endeavors:

- In 1996, only 12 countries had Internet access. Now, all of the 54 countries & territories in Africa have public local dialup Internet access services in the capital cities.
- Almost 20 new mobile networks were launched in Africa between 1997 and 1998. The number of cellular subscribers in the continent neared the two million mark in 1997.
- Mobile communication lines grew by 65% in 97-98; they now represent at least 20% of Africa's fixed network.

The onset of (more) affordable new technologies such as wireless and video communication poses interesting options to the tools that have been developed thus far.

Especially in terms of the content of programs like CASCADE-SEA, Hawkridge (1994, p. 110) suggests: "It is time for a much more substantial study to improve understanding of the issues and solutions. Educational technology is not value-free, and educators cannot assume that educational technology developed in their own country is appropriate to another, without modification. Research on what modification is required for each country is essential." Toward this end, it makes sense to explore what aspects, if any, of the existing system make sense within a more narrowly-defined context, such as one country. Having been warned against the "wholesale transplantation" of ideas (Ogunniyi, 1996), it makes sense to capitalize on existing local enthusiasm (for the use of CASCADE) to create additional avenues for exploration.

Between the need for collaborative research on curriculum development and implementation, particularly in developing countries (Montero-Sieburth, 1992), and the value of joint projects within and across countries (Davis, 1994), it would seem that a next logical step in the CASCADE family lineage should be a cooperative implementation study. Teamwork such as this might not only help facilitate user-centered design, but could also offer the opportunity to study what elements of a system such as CASCADE are more subject to (micro)context variation and which ones are generic. For example, if a multi-country (tailoring and) implementation study were initiated, findings both within and across contexts could be compared and contrasted. Additionally, implementation studies offer the opportunity to explore scale and scalability issues that are less related to designing tools like this and more focused on optimizing associated implementation processes.

6.3.2 Development research of this nature

In addition to ideas regarding the CASCADE product, this study has contributed to the development of insights about the process through which it evolved. With potential application to future endeavors in mind, this section briefly examines highlights of those insights. Here, the importance of adaptability in design and development processes is examined with regard to prototyping in particular, and ICT-related innovations in developing countries in general.

Adaptive design and development practices
Earlier discussion in this chapter illustrated how a pre-disposition to adaptability helped address a number of dilemmas that cropped up throughout the CASCADE-SEA study. This section looks at two examples that may be useful in other situations, concerning design and development practices, respectively.

Many EPSS developers struggle to strike a useful balance between generic and content-specific support. As Nieveen (1997, p. 221) writes, "A system which provides tailor-made support may be too rigid for professionals who wish a large degree of freedom in their choices; whereas a system which provides general support is applicable in many contexts, but increases the chance that the support remains trivial." Prototyping and successive formative evaluation have led to a support arrangement in CASCADE-SEA that could also be transplanted to other systems that grapple with this issue: a careful combination of heuristics and examples. The CASCADE-SEA program offers design principles in combination with good quality subject-specific examples. For instance, users creating biology lessons are presented with generic tips (such as a list of action verbs to get a start on writing objectives) while many samples and templates presented to them relate to the field of biology (and, if they so choose, to their specific topic).

Such a design could easily be transplanted into other programs, and was applied in this study because it yields both practical advantages for the development of the system, as well as increased potential for learning as a result of using the tool. From a practical standpoint, this helps the developers to maintain focus on offering good quality, general task support (in this case, for materials design). With an eye toward extending the program (in this case, to address additional subject areas or to deepen existing support), this approach keeps more options open for future elaboration. That is, general tips can remain the same while only the range of examples is expanded. This approach is especially beneficial for systems that aim to promote user learning (in the case of CASCADE-SEA, about the process of creating exemplary lesson materials). Learning takes place by offering (generic) heuristics and explaining why they are important, as well as giving (tailor-made, specific) examples that are meaningful and relevant to the user. The result is a lowered threshold for the transfer of new insights to the user's own task-related activities.

In addition to planning for expansion in terms of the support offered inside an EPSS, a prototyping course of action stands to benefit from similar preparation. While the term prototyping implies evolution and change, the nature and degree of product growth can be limited, depending on when revision activities are undertaken, who is involved and how their input is solicited. Based on the CASCADE-SEA experience, the following text presents some dilemmas associated with innovative program development, and ways to address them.

It is often the computer programmer's inclination to try to perceive the ultimate, most elaborate version of a system (starting in early stages) so that functionality can then be designed according to all possible needs. Such an approach often entails a broad orientation and then (relatively) slow, steady, integrated development of the various components: horizontal prototyping. From a 'neatness of code' standpoint, this is likely to yield clean, well-flowing programming. In terms of being able to scale up quickly and easily from an initial version to that elaborate version, this can also prove quite useful.

However, in innovative cases where the product specifications have yet to be generated or confirmed, this kind of an approach can be counter-productive. Especially when content or context specialists (as opposed to computer programmers) are part of the design team, such an approach can be overwhelming. The main pitfall is that it tends to draw attention away from the pedagogical and/or task-based concerns, and shine a spotlight on technical possibilities. Rather than designing from the perspective of analyzing a situation and then selecting the best tool for the job, this type of approach frequently pushes a variety of (potentially interesting and valuable) tools to the content specialist with the assignment of deciding how or where to use them inside the program. Given the well-known pitfall of considering the use of ICT as a goal in itself rather than a means to a particular end, this comes as no surprise. Nonetheless, it is a dangerous path to follow, especially when co-designers have had little exposure to computer programming, and are easily swept up in issues related to 'what can be' instead of 'what should be.'

An alternate approach for a collaborative design team is that of vertical prototyping. In this case, a relatively shallow model of the overall design is drafted, and then chunked into logical sections. These chunks are then elaborated (in depth), more or less independent of the other sections of the program. Although not necessarily the preferred method for all projects, this kind of prototyping can offer several advantages, especially to development teams who are still engaged in hammering out their product specifications. First, this strategy forces the designer to think concretely about various aspects of the program from early on. It mitigates the temptation to become swept up in the technical possibilities, by bringing such opportunities directly into view and demanding deeper thought. For example, in one section of the program, the developer might be enraptured by the idea of offering an array of text-based templates for lesson planning. The issue of how (technically) to present such templates to the user pales in comparison to the task of developing such templates. Secondly, as with most forms of instructional design, even well-thought out plans generally come to fruition in a format different from the intended one (for better or worse). Engaging developers in content-based tasks (such as the development of text-based lesson templates) is often a fruitful way to uncover glitches in thought, or to realize how principles that work well in one area of the program may be applied to another. Finally, this approach welcomes the active involvement of the target users in development. This not only increases their ownership in the project (a factor which can strongly influence its ultimate implementation), but also serves to increase the overall quality of the system, particularly in terms of its practicality. Vertical prototyping can be time-consuming for the design team as well as difficult for the programmer in the short run. But, if conducted carefully, this approach is likely to deepen the overall quality of a program, and may even save effort (on behalf of both designers and developers) in the long term.

CASCADE-SEA in a broader perspective

Anzalone (1991) predicted an increased recognition for the importance of sound instructional design in the creation of curriculum materials in developing countries; he further stated that the development of related capacities would undoubtedly be aided by computers. A step in this direction, the CASCADE-SEA study has illustrated that the computer does have the potential to support curriculum development and teacher professional development in southern Africa. It has also highlighted the determining role of the context in which it will be used toward realizing that potential. Input from expert and user groups has indicated that this program (and/or a tailored version hereof) may be particularly useful to professional curriculum developers and preservice teachers, in addition to the target user group: facilitator teachers working at TRCs.

Realizing that CASCADE-SEA is merely a tool to be employed by interested parties, the examination of promising implementation strategies should thus be a priority in future activities. This includes studying the integration of this system into professional development programs and its flexible application within resource centers. Further, opportunities to grow professionally should be made available in such a way as to capitalize on the motivation of (potential) users (cf. Fullan, 1991). At the same time, since tools for instructional design and curriculum development not only incorporate present knowledge in these areas, but also contribute to this type of knowledge (Wilson & Jonassen, 1991), efforts should be made to distill lessons from these future endeavors. In particular, researchers and developers should strive toward understandings that are culturally and socially portable (i.e. for [adapted] use in various contexts). According to Murray-Lasso (1990), the chances for success in this area can be greatly increased through international cooperation in terms of information exchange and collaborative development of software as well as the active participation of teachers from the target setting.

As this line of inquiry moves forward, insights should be sought into the achieved (not only potential) impact of implementing a program like CASCADE-SEA, as well as factors affecting that impact. Because such endeavors would likely involve further software development (improvements, expansions and local adaptations), questions begin to arise with regard to testing the limits of university-based research and development. At what point should academia leave off and commercial enterprise begin? How should trade-off decisions concerning benefits and risks of out-sourcing product development be weighed? Answers to these questions are likely to be multi-dimensional, complex and situationally-grounded. While results of this study certainly do not address these issues directly, the five tenets that molded the foundation of this research may provide a framework for dialogue.

These tenets may also form a useful framework for addressing additional questions concerning ICT-related development research, particularly in developing countries. So, in light of the reflections presented in this chapter, the foundational tenets are revisited, once more. Based on these ideas, this book concludes with recommendations for continued and related research and development efforts concerning educational applications of ICT in developing countries, such as CASCADE (see Table 6.1, next page).

	What to consider	Deliberation tips
Local relevance	Examine the target setting, together with the target group, to determine if the proposed innovation really addresses an expressed need in a culturally and contextually relevant fashion. Consider alternate versions of the innovation that address potential (long or short term) problems.	To succeed, innovations usually require the time and energy of the participants. Look carefully at what those people do (or, often more important, what they do *not* do) and why. Use this information to help capitalize on participants' intrinsic motivation to invest in the innovation.
Collaboration	Few, if any participants in innovation, are experts on all types of educational developments. Especially in new and inventive areas involving ICT, people tend to have less experience and therefore may have difficulty in contributing to certain dialogues. Expend effort to determine ways in which all participants can provide input in a fruitful and appropriate fashion.	Rather than overwhelming participants with wonderful sounding techno-possibilities, engage people in tasks that relate to those aspects of the innovation with which they are *already familiar*, and pay attention to what they indicate to be areas of concern, strengths or challenges.
Authenticity	All over the world (not only in developing countries), educational change is considered difficult, if not impossible to steer. At most, authorities may hope to shepherd developments in a particular direction. To do so, educational innovations must illustrate how they relate to what is already known and understood. The more genuine the test situation, the more genuine the results will be. It pays off to invest time and energy in seeking out naturally-occurring test-beds for product design, development, evaluation and revision.	Study what (if anything) has fostered successful change in the past. Determine how this innovation will connect with existing frameworks and the target population's own motivation, own facilities, own needs, as well as other on-going developments. This requires creative approaches to collecting useful information while maintaining the focus on the better interests of all parties involved.
Mutual benefit	Consider the main goals of the innovation and then look for micro-settings in which these things are already taking place (usually in a less explicit fashion). Capitalize on existing efforts toward both gaining additional support for the innovation and improving its overall quality and impact. The reality in developing countries is that most schools are poorly resourced and most teachers are un(der) qualified. If the innovation relies on more educated personnel or better facilities, take it to a logical 'home' where this may be found.	In the use of ICT in education, TRCs (teacher resource centers) and community centers are generally better equipped than schools. This pertains to physical infrastructure as well as the facilitator staff that provide support. In terms of the broader perspective, such centers (have the potential to) contribute to the overall growth of the community and may serve various sectors (education, health, business etc.) simultaneously.
Continuous (re)analysis	ICT is a field subject to rapid and unpredictable change. Particularly where resources are scarce (in developing countries), it is prudent to carefully examine how innovations may be structured for the long term. Take into account the current realities that are part of the 'bigger picture,' (e.g. telephone lines or electricity).	Study the interplay between the *state-of-the-art* worldwide and the *state of practice* in the target setting. Consider the innovation in its ideal form, but (as much as possible) work toward that goal within the limits of current infrastructure and readiness-levels.

Table 6.1: Considerations for research and development activities pertaining to ICT applications in developing countries

To date, little research has been published in the area of computer-based support for curriculum development in developing countries. And whether or not outputs of this study will be used to inform future activities remains to be determined. Yet the CASCADE-SEA expedition has shown that, if carefully embedded into existing activities where a need and a readiness exists, such an approach can be potentially advantageous. It is hoped that this realization will promulgate additional inquiries into this promising domain.

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Appendices

Appendix A: Data collection circuits overview

Activity Circuit overview

Unless otherwise specified, the primary developer carried out the research activities for each circuit

Phase	Cycle	Circuit sequence and name	Description
Needs and context analysis	*Literature review & concept validation*	1: NL1	An expert appraisal conducted with five Dutch experts in the Netherlands
		2: AMSTIP	An expert appraisal conducted with five science teacher educators visiting from Lesotho
		3: TEAMS1	An expert appraisal conducted in the Netherlands with three visiting colleagues from this science education improvement program in Tanzania
		4: SEITT1	Five members of the (SEITT) science education improvement program staff planned formative evaluations with the aid of the CASCADE program
	Site visits (discussion tool)	5: SAARMSE	Respondents (n=13) participated in an expert appraisal held at the Southern African Association for Science and Mathematics Education conference
		6: UB	The University of Botswana hosted the micro-evaluation activities which included a seminar and a workshop
		7: TEAMS2	Additional staff (n=3) from the TEAM's group participated in an expert appraisal held in Dar es Salaam
Design, development and formative evaluation of prototypes	*Prototype 1*	8: DEV1	The development team (n=4) conducted screenings during each prototyping cycle
		9: PSU/UGA/ USA	The first round of expert appraisal (n=15) on the initial prototype took place through site visits to various universities in the USA
		10: NL2	This expert appraisal took place at two universities in the Netherlands with 19 experts in various fields
		11: NL3	Twelve curriculum development and performance support experts helped to generate tentative design specifications
	Prototype 2	12: DEV2	The development team (n=4) conducted screenings during each prototyping cycle
		13: SEITT2	Respondents (n=25) associated with this science education improvement program participated in two workshops held with the first prototype
		14: TEAMS3	In this week-long writers workshop, 25 respondents tried out the second prototype

Table A1: Activities circuit overivew *(continued on next page)*

Design, development and formative evaluation of prototypes	*Prototype 3*	15: DEV3	The development team (n=4) conducted screenings during each prototyping cycle
		16: SW	At a regional seminar for teacher educators, participants (n=12) conducted an expert appraisal
		17: UN	A brief (half-day) expert appraisal was carried out with three participants from the University of Natal
		18: SEITT3	A mixed group of experts (n=10) participated in this expert appraisal in Zimbabwe
		19: SEITT4	*(Carried out by a Dutch masters student enrolled in Twente's graduate program)* this micro-evaluation involved both users and experts associated with the SEITT program
		20: TEAMS4	*(Carried out by Tanzanian Masters student enrolled in Twente's graduate program)* this micro-evaluation took place in Tanzania, in cooperation with the TEAM's staff
		21: UNESCO1	*(Carried out by Zimbabwean Masters student enrolled in Twente's graduate program)* this micro-evaluation explored the possibility of using CASCADE-SEA in preservice education in Zimbabwe
		22: PTLC	*(Carried out by two Dutch Masters students enrolled in Twente's graduate program)* this micro-evaluation collected information during two three-day workshops in Namibia
		23: RSA1	*(Carried out by a Dutch Masters student enrolled in Twente's graduate program)* this micro-evaluation explored the potential of CASCADE-SEA to form a viable solution to some of the issues and challenges brought into play by the introduction of Curriculum 2005 in South Africa
		24: RSA2	*(With the aid of a research assistant)* this expert appraisal was also conducted in South Africa with experts from various institutions
	Prototype 4	25: DEV4	The development team (n=4) conducted screenings during each prototyping cycle
		26: NAM	A brief expert appraisal was carried out in Windhoek during a two-hour seminar
		27: CET	*(With staff support)* This tryout took place in cooperation with the University of Zimbabwe's Center for Education Technology
		28: SEITT5	The SEITT program's residential training period provided the venue for this tryout
		29: UNESCO2	*(With the aid of a research assistant)* Five two-day workshops were sponsored by UNESCO in Zimbabwe, and served as micro-evaluations in this study
		30: SHOMA	*(Carried out by two Dutch Masters students, one enrolled in Twente's graduate program and the other in Leiden)* this tryout explored the potential of CASCADE-SEA to support South African teachers in association with the SHOMA foundation
Semi-summative evaluation	*Final evaluation*	31: TEAMS5	The final version of the program was tried out during a materials writing workshop in Tanzania
		32: NL4	A final expert appraisal was organized at the University of Twente
		33: NSDSI	The final version of the program was tried out during a Nambian facilitator-teacher training program in the Netherlands
	Query	34: QUERY	The final version of the program was sent out to interested colleagues with the invitation to comment on the system itself, as well as future directions for this line of inquiry

Table A.1: Activities circuit overview

Appendix B: Instruments and respondents overview

Phase	Cycle	Circuit	Instrument Code	Brief description	RI	Types of Respondents	RC
Needs and context analysis	Concept Validtation	1	D-NL1	Demonstration	5	Sci ed/ ed in dev countries sp.	5
		2	D-AMSTIP	Translated Demonstration	5	Visitors from this educational improvement program in Lesotho	5
		3	D-TEAMS1	Demonstration	3	Visitors from this educational improvement program in Tanzania	3
		4	DG-SEITT1	Hands-on workshop	5	Project staff	5
	Site visits	5	Q-SAARMSEa	Context	13	Hands-on workshop attendees at the SAAREMSE conference	24
			Q-SAARMSEb	General user	10		
			Q-SAARMSEc	Specific user	1		
			DG-SAARMSE	Discussion	24		
		6	IS-UB	Open interview	4	Students in the faculty of education at UDSM	27
			DG-UB	Demonstration	23	Students and teachers from the faculty of education at UDSM	
		7	IS-TEAMS2	Walkthrough	3	Projects staff from TEAMS	3
Design, development and formative evaluation of prototypes	Prototype 1	8	W-DEV1	Screenshots	4	Developer group	4
		9	IS-PSU/UGA/USA	Walkthrough	15	Instructional designers/curriculum developers and EPSS specialists	15
			D-PSU	Demonstration	8	Instructional designers	
		10	W-NL2	Walkthrough	19	Curriculum developers, science education and EPSS specialists	19
		11	DG-NL3a-d	Hands-on	12	Curriculum developers	12
	Prototype 2	12	W-DEV2	Walkthrough	4	Development team	4
		13	D-SEITT2	Demonstration	25	Science and mathematics facilitator teachers	25
		14	Q-TEAMS3	Post use	31	Science and mathematics facilitator teachers during a hands-on workshop	34
			DG-TEAMS3	Demonstration	34		
			DA-TEAMS3	Lesson plans	3		
			O-TEAMS3	Hands-on	34		
	Prototype 3	15	W-DEV3	Walkthrough	4	Development team	4
		16	D-SW	Hands-on workshop	12	SMART workshop participants	12
		17	D-UN	Demonstration	5	IPEB Univ Natal	3
		18	D-SEITT3	Demonstration	10	Ministry of Education officers	10
		19	IS-SEITT4	Expert opinion	4	SEITT staff	33
			Q-SEITT4c		4		
			O-SEITT4	Hands-on workshop	28	Facilitator teachers	
			Q-SEITT4a	Pre-use questionnaire	23		
			Q-SEITT4b	Post use questionnaire	29		
			DG-SEITT4	After use discussion	27		
			L-SEITT4	Reactions during use	13		
			DA-SEITT4	Lessons made	12		

Table B.1: Instruments and respondents overview *(continued on next page)*

Phase	Cycle	Circuit	Instrument Code	Brief description	R I	Types of Respondents	R C
Design, development and formative evaluation of prototypes	Prototype 3	20	IS-TEAMS4	Pre-use	4	STIP & TIE staff	18
			Q-TEAMS4a	Pre-use	12	Pre-service teachers	
			Q-TEAMS4b	Pre-use	7	TEAMS & SESS staff	
			Q-TEAMS4c	TRC info	2	TRC staff	
			Q-TEAMS4d	Pre-use	6	TIE officials	
			Q-TEAMS4e	post-workshop questionnaire	16	TEAMS, pre-service, TIE, STIP & SESS staff	
			O-TEAMS4	Hands-on workshop	16		
			DA-TEAMS4	Lesson plans	2		
		21	IS-UNESCO1	Semi-open	4	Pre-service teachers, lecturers at TTCs and UNESCO staff	19
			DA-UNESCO1	Lessons made	5		
			Q-UNESCO1a	Pre-use questionnaire	15	Pre-service teachers, lecturers at TTCs	
			Q-UNESCO1b	Post-use questionnaire	15		
			DG-UNESCO1	Following workshop	15		
			O-UNESCO1	Hands-on workshop	15		
			L-UNESCO1	Reactions during use	15		
		22	Q-PTLCa	Entry questionnaire	17	Science and non-science teachers	18
			Q-PTLCd	TAC pre-use questionnaire	14		
			Q-PTLCe	TAC post-use questionnaire	14		
			O-PTLC	Hands-on workshop	18		
			Q-PTLCb	Reflective questionnaire for science teachers	7	Science teachers	
			IS-PTLC	Post-use interview	6		
			Q-PTLCc	Reflective questionnaire for non-science teachers	9	Non-science teachers	
			DG-PTLC	Post-use focus group	7		
		23	Q-RSA1a	Pre-use questionnaire	30	Science and mathematics teachers	30
			Q-RSA1b	Open questions	30		
			Q-RSA1c	Structured questions	28		
			DG-RSA1	Workshop discussion	30		
			O-RSA1	Hands-on workshop	30		
			L-RSA1	File Information	29		
		24	Q-RSA2	Open questions	22	Didactics participants; Port Elizabeth Technikon, University of Pretoria, Onderwyscollege Pretoria	22
			DG-RSA2	Demonstration discussion	18		

Table B.1: Instruments and respondents overview (continued on next page)

Phase	Cycle	Circuit	Instrument Code	Brief description	RI	Types of Respondents	RC
Design, development and formative evaluation	Prototype 4	25	W-DEV4	Walkthrough	4	Developers	4
		26	DG-NAM	Demonstration discussion	11	MOEC meeting	11
			Q-NAM		6		
		27	Q-CETa	Hands-on workshop	3	CET program participants	11
			Q-CETb		3		
			DG-CET		11		
			O-CET		11		
		28	Q-SEITT5a	Hands-on workshop	29	Facilitator teachers during residential period	44
			Q-SEITT5b		41		
			O-SEITT5		29		
			DG-SEITT5		3	Facilitator teacher educators	
		29	Q-UNESCO2	Five (semi) hands-on workshops	54	Facilitator, inservice and preservice teacher educators	54
			DG-UNESCO2				
			O-UNESCO2				
			L-UNESCO2				
		30	IS-SHOMAa	Pre-use	3	Shoma management	16
			IS-SHOMAb	Post-use	2	Shoma facilitators	
			IS-SHOMAc	Post-use	4	Teachers participating in Shoma program	
			Q-SHOMAa	Background	11		
			Q-SHOMAb	Post-use	9		
			Q-SHOMAc	Post-workshop	11		
			Q-SHOMAd	Improvements	2		
			O-SHOMAa	Reflection	4		
			O-SHOMAb	Objective	1		
			DA-SHOMA	Products made	4		
Semi-summative evaluation	Final Evaluation	31	Q-TEAMS5a	Detailed	5	Full-time users	19
			DG-TEAMS5	Open	5		
			O-TEAMS5	Hands-on	5		
			DA-TEAMS5	Products made	3		
			Q-TEAMS5b	General	19	All at workshop	
		32	Q- NL3	Post-use	17	Curriculum develoment, ed in dev countries & epss experts	17
			DG- NL3	Thematic	17		
			O-NL3	Hands-on	17		
			DA-NL3	Posters	9		
		33	Q-NSDSI	End of course	1	Namibian facilitator teachers	9
			DG-NSDSI	In class	9		
			O-NSDSI	During use	9		
			L-NSDSI	Each meeting	9		
			DA-NSDSI	Assignments	9		
	Query	34	Q-QUERY	Query toward future	34	Interested parties	34
Estimated total respondents when corrected for those who participated in more than one cycle: 511							

Table B.1: Instruments and respondents overview

Legend

RI = Total number of respondents for this instrument/procedure
RC = Total number of respondents per circuit (individuals participating more than one time in a circuit are counted only once)
IS = Interview scheme
W = Walkthrough scheme
Q = Questionnaire
DG = Discussion guide
O = Observation scheme
D = Demonstration guide
L = Log book
DA = Document analysis checklist

Appendix C: Instruments used in this study

The following table presents an overview of the 108 instruments used throughout this study. Due to practical considerations, (documents range from one to five pages in length), these instruments are available in electronic format only. To view these documents, insert the CD-ROM (located at the back of this book) into the proper computer drive, open the electronic version of this page, and click an instrument in the table (next page); the corresponding file will open automatically, (providing Adobe Acrobat Reader™ is installed). Alternatively, visit:
Http://projects.edte.utwente.nl/cascade/seastudy/

Phase	Cycle	Interview & Walkthrough Schemes	Questionnaires	Discussion Guides	Observation & Demo Schemes	Logbooks	Document Analysis Checklists
Analysis	LR			DG-SEITT1.4	D-NL1.1 D-AMSTIP.2 D-TEAMS1.3		
	SV	IS-UB.6 IS-TEAMS2 7	Q-SAARMSEa.5 Q-SAARMSEb.5 Q-SAARMSEc.5	DG-SAARMSE.5 DG-UB.6			
Design, Development and formative evaluation	P1	W-DEV1.8 IS-PSU/UGA/ USA.9 W-NL2.10		DG-NL3a.11 DG-NL3b.11 DG-NL3c.11 DG-NL3d.11	D-PSU.9		
	P2	W-DEV2.12	Q-TEAMS3.14	DG-TEAMS3.14	D-SEITT2.13 O-TEAMS3:14		DA-TEAMS3:14
	P3	W-DEV3.15 IS-SEITT4.19 IS-TEAMS4.20 IS-UNESCO1.21 IS-PTLC.22	Q-SEITT4a.19 Q-SEITT4b.19 Q-SEITT4c.19 Q-TEAMS4a.20 Q-TEAMS4b.20 Q-TEAMS4c.20 Q-TEAMS4d.20 Q-TEAMS4e.20 Q-UNESCO1a.21 Q-UNESCO1b.21 Q-PTLCa.22 Q-PTLCb.22 Q-PTLCc.22 Q-PTLCd.22 Q-PTLCe.22 Q-RSA1a.23 Q-RSA1b.23 Q-RSA1c.23 Q-RSA2.24	DG-SW.16 DG-SEITT4.19 DG- UNESCO1.21 DG-PTLC.22 DG- RSA1.23 DG-RSA2.24	D-UN.17 D-SEITT3.18 O-SEITT4.19 O-TEAMS4.20 O-UNESCO1.21 O-PTLC.22 O- RSA1.23	L-SEITT4.19 L-UNESCO1.21 L- RSA1.23	DA-SEITT4.19 DA-TEAMS4.20 DA- UNESCO1.21
	P4	W-DEV4.25 IS-SHOMAa.30 IS-SHOMAb.30 IS-SHOMAc.30	Q-NAM.26 Q-CETa.27 Q-CETb.27 Q-SEITT5a.28 Q-SEITT5b.28 Q-UNESCO2.29 Q-SHOMAa.30 Q-SHOMAb.30 Q-SHOMAc.30 Q-SHOMAd.30	DG-NAM.26 DG-CET.27 DG-SEITT5.28 DG- UNESCO2.29	O-CET.27 O-SEITT5.28 O-UNESCO2.29 O-SHOMAa.30 O-SHOMAb.30	L-UNESCO2.29	DA-SHOMA.30
Evaluation	FE		Q-TEAMS5a.31 Q-TEAMS5b.31 Q- NL3.32 Q-NSDSI.33	DG-TEAMS5.31 DG- NL3.32 DG-NSDSI.33	O-TEAMS5.31 O-NL3.32 O-NSDSI.33	L-NSDSI.33	DA-TEAMS5.31 DA-NL3.32 DA-NSDSI.33
	Qu		Q-QUERY.34				

Table C.1: Instruments matrix

Legend

LR = Literature review
SV = Site visits
P1 = Prototype 1
P2 = Prototype 2
P3 = Prototype 3
P4 = Prototype 4

FE = Final evaluation
Qu = Query
IS = Interview scheme
W = Walkthrough scheme
Q = Questionnaire

DG = Discussion guide
O = Observation scheme
D = Demonstration guide
L = Log book
DA = Document analysis checklist

Appendix D: Prototype two decision-making

Internal document: January, 1998

The expert appraisals carried out on the first CASCADE-SEA prototype in late 1997 have yielded a set of design specifications which may be used to continue development in various areas of the CASCADE-SEA program. As this research is being conducted in conjunction with external projects (such as the TEAMS project in Tanzania), it would seem that any temporal priorities in terms of what changes are made first and which ones are saved for later, should be influenced by the needs of the cooperating parties.

The TEAMS project is currently planning a "Trainer of Trainers Materials Writing Workshop" for late March, and had indicated interest in trying out (components of) the CASCADE-SEA prototype at this time. Such a venture would afford an opportunity for the designer to gain better insight into the actual field setting, while also offering a chance to try out (some of) the CASCADE-SEA prototype.

Due to the brief amount of time between the most recent evaluation and the next significant research opportunity, it would be impossible to implement all of the revision changes before the Writer's Workshop in March. This means that determining which area should be targeted for immediate revision should be based on the anticipated needs at this workshop as well as a realistic estimation of what can be completed in the time available.

The following components of CASCADE-SEA are currently being considered for revisions within the next month, to be used during the March workshop:

- building a rationale
- lesson builder
- a tool for the division and sequencing of content

Salient arguments can be made for and against selecting any of these components for revision and use within the upcoming workshop, as the following table illustrates.

Arguments for and against the tools being considered for immediate development

tool for:	reasons to postpone	reasons to pursue
rationale	This is a most complex challenge in terms of determining how CASCADE-SEA will define a rationale, and in terms of being able to support the user in creating one. Knowing what issues are covered in other areas (of this prototype) might yield a finer grasp on how to structure this particular component.	This is the hub around which CASCADE-SEA will revolve. Its critical importance makes it a priority.
lessons	Ultimately, developers would like to link this area of CASCADE-SEA to a database. Then, users would be able to share the building blocks created by their colleagues in building their own lessons. This requires significant temporal investment in order to technically realize the link with the database, as well as to create sufficient sample material to enter into the database. The current limited time available for development will probably force (temporary) compromise(s). It might be better to work on this area when more time is available.	The end result of using the lesson builder will be that CASCADE-SEA generates the user's lesson and opens this document in a word processor, where it may be revised and edited or printed out. Thus, the degree of 'instant gratification' offered in this area of CASCADE-SEA is particularly high. Taking the ultimate implementation of CASCADE-SEA into consideration, this component has the potential to improve implementation conditions by significantly motivating the users, even if they are testing out a 'young' version of this component.
Content	This tool will employ two main components: general guidelines for concept mapping/ sequencing and context-rich, case sensitive examples. Both components are well elaborated, such that this tool may be assembled relatively easily. However, many of the case-sensitive examples (such as subject-area concept maps) are currently only available in paper-based form. Creating the examples in concept map (file) format is an easy, yet time-consuming task. Perhaps this job could be started (by an assistant) while another tool is worked on first. Then, all the 'pieces' needed to fully assemble this tool would be ready at once.	Various tools and heuristics for the division and sequencing of content have been surveyed and considered, such that the design specifications for this tool are well elaborated. As a result, the main structure of this component should be relatively easy to put together, which might allow time for an additional round of (internal) testing before being used with the target group (though the examples might not be ready immediately). Such testing might eradicate any major problems or difficulties, thus making optimal use of field testing opportunities.

Table D.1: Decision making matrix

The arguments for and against each of the tools being considered for immediate attention, together with the perceived needs and interests of the organizers of the writers' workshop, have influenced the developmsent team's decision-making process with regard to which area will be elaborated next. The component selected for immediate revision is the lesson builder. At the same time, the process of translating the (currently paper-based) concept maps into file format will be started, with the hope of having them completed in time to prepare for the second writers' workshop, currently scheduled for August, 1998. Such an approach would allow sufficient time to prepare a fully revised prototype (including the rationale component) for a larger-scale try-out in 1999. As both TEAMS and SEITT are scheduled to be running facilitator training courses in or around May of 1999, this planning seems sound.

Appendix E: Microsoft's user-centered design principles

From *Microsoft Windows User Experience* by Microsoft Corporation.

The information in this section describes the design principles on which Windows and the guidelines in this book [*Microsoft Windows User Experience*] are based. You will find these principles valuable when designing software for Windows.

User in Control

An important principle of user interface design is that the user should always feel in control of the software rather than feeling controlled by the software. This principle has a number of implications:

- The operational assumption is that the user — not the computer or software — initiates actions. The user plays an active rather than reactive role. You can automate tasks, but implement the automation in a way that allows the user to choose or control it.
- Because of their widely varying skills and preferences, users must be able to personalize aspects of the interface. The system software provides user access to many of these aspects. Your software should reflect user settings for different system properties, such as colors, fonts, or other options.
- Your software should be as interactive and responsive as possible. Avoid modes whenever possible. A *mode* is a state that excludes general interaction or otherwise limits the user to specific interactions. When a mode is the best or only design alternative — for example, for selecting a particular tool in a drawing program — make sure the mode is obvious, visible, the result of an explicit user choice, and easy to cancel.

Here are some other suggested ways of keeping your application's design interactive:

- Use *modeless* secondary windows wherever possible.
- Segment processes, such as printing, so you do not need to load the entire application to perform an operation.
- Run long processes in the background, keeping the foreground interactive. For example, when a document is printing, the user should be able to minimize the window even if the document cannot be altered. The multitasking support in Windows allows you to define separate processes, or *threads*, in the background.

Directness

Design your software so that users can directly manipulate software representations of information. Whether they are dragging an object to relocate it or navigating to a location in a document, users should see how their actions affect the objects on the screen. Visible information and choices also reduce the user's mental workload. Users can recognize a command more easily than they can recall its syntax.

Familiar metaphors provide a direct and intuitive interface for user tasks. By allowing users to transfer their knowledge and experience, metaphors make it easier to predict and learn the behaviors of software-based representations.

When using metaphors, you need not limit a computer-based implementation to its real-world counterpart. For example, unlike its paper-based counterpart, a folder on the Windows desktop can be used to organize a variety of objects such as printers, calculators, and other folders. Similarly, a Windows folder can be sorted in ways that its real-world counterpart cannot. The purpose of using metaphor in the interface is to provide a cognitive bridge; the metaphor is not an end in itself.

Metaphors support user recognition rather than recollection. Users remember a meaning associated with a familiar object more easily than they remember the name of a particular command.

Consistency

Consistency allows users to transfer existing knowledge to new tasks, learn new things more quickly, and focus more attention on tasks. This is because they do not have to spend time trying to remember the differences in interaction. By providing a sense of stability, consistency makes the interface familiar and predictable.

Consistency is important through all aspects of the interface, including names of commands, visual presentation of information, operational behavior, and placement of elements on the screen and within windows. To design consistency into software, you must consider the following:

- Consistency within an application. Present common functions using a consistent set of commands and interfaces. For example, avoid implementing a *Copy* command that immediately carries out an operation in one situation but in another displays a dialog box that requires a user to type in a destination. As a corollary to this example, use the same command to carry out functions that seem similar to the user.
- Consistency within the operating environment. By maintaining a high level of consistency between the interaction and interface conventions

provided by Windows, your software benefits from the users' ability to apply interactive skills they have already learned.

- Consistency with metaphors. If a particular behavior is more characteristic of a different object than its metaphor implies, the user may have difficulty learning to associate that behavior with an object. For example, an incinerator communicates a different model than a wastebasket as far as recovering the objects placed in it.

Forgiveness

Users like to explore an interface and often learn by trial and error. An effective interface allows for interactive discovery. It provides only appropriate sets of choices and warns users about potential situations where they could damage the system or data, or better, makes actions reversible or recoverable.

Even in the best-designed interface, users can make mistakes. These mistakes can be both physical (accidentally pointing to the wrong command or data) and mental (making a wrong decision about which command or data to select). An effective design avoids situations that are likely to result in errors. It also accommodates potential user errors and makes it easy for the user to recover.

Feedback

Always provide feedback for a user's actions. Good feedback helps confirm that the software is responding to input and communicates details that distinguish the nature of the action. Effective feedback is timely and is presented as close to the point of the user's interaction as possible. Even when the computer is processing a particular task, provide the user with information about the state of the process and how to cancel the process if that is an option. Nothing is more disconcerting to users than a "dead" screen that is unresponsive to input. A typical user will tolerate only a few seconds of an unresponsive interface.

It is equally important that the type of feedback you use be appropriate to the task. You can communicate simple information through pointer changes or a status bar message; for more complex feedback, you may need to display a progress control or message box.

Aesthetics

Visual design is an important part of an application's interface. Visual attributes provide valuable impressions and communicate important cues to the interactive behavior of particular objects. At the same time, it is important to remember that every visual element that appears on the screen potentially competes for the user's attention. Provide a coherent environment that clearly contributes to the user's understanding of the information presented. The skills of a graphics or visual designer can be invaluable for this aspect of the design.

Simplicity

An interface should be simple (not simplistic), easy to learn, and easy to use. It must also provide access to all functionality of an application. Maximizing functionality and maintaining simplicity work against each other in the interface. An effective design balances these objectives.

One way to support simplicity is to reduce the presentation of information to the minimum required to communicate adequately. For example, avoid wordy descriptions for command names or messages. Irrelevant or verbose phrases clutter your design, making it difficult for users to extract essential information easily. Another way to design a simple but useful interface is to use natural mappings and semantics. The arrangement and presentation of elements affects their meaning and association.

Simplicity also correlates with familiarity; things that are familiar often seem simpler. Whenever possible, try to build connections that draw on your users' existing knowledge and experiences.

You can also help users manage complexity by using progressive disclosure. *Progressive disclosure* involves careful organization of information so that it is shown only at the appropriate time. By hiding information presented to the user, you reduce the amount of information the user must process. For example, you can use menus to display lists of actions or choices, and you can use dialog boxes to display sets of options.

Progressive disclosure does not imply using unconventional techniques for revealing information, such as requiring a modifier key as the only way to access basic functions or forcing the user through a longer sequence of hierarchical interaction. This can make an interface more complex and cumbersome.

Appendix F: Product specifications

The following table presents an overview of the specification documents used to create the CASCADE-SEA program, as discussed in Chapter 4. Due to practical considerations (documents range from one to seven pages in length), these documents are available in electronic format only. To view them, insert the CD-ROM (located at the back of this book) into the proper computer drive, open the electronic version of this page, and click a file name in the table below; the corresponding file will open automatically (providing Adobe Acrobat Reader™ is installed). Alternatively, visit: Http://projects.edte.utwente.nl/cascade/seastudy/

File name	Specification description
Appendix F-1	Rationale ideas
Appendix F-2	Rationale template (I)
Appendix F-3	Rationale template (II)
Appendix F-4	Analysis design specifications (I)
Appendix F-5	Analysis design specifications (II)
Appendix F-6	Analysis design specifications (III)
Appendix F-7	Analysis design specifications (IV)
Appendix F-8	Analysis questions overview
Appendix F-9	Lesson builder projected features
Appendix F-10	Lesson builder master choice list

Box F.1: Specifications matrix

Note to the reader: As mentioned in Chapter 4, product specifications for the evaluation component were derived from those generated for the original CASCADE program. Please refer to Nieveen (1997) for detailed specification information on this component.

Appendix G: The CASCADE-SEA program

This appendix is contains the CASCADE-SEA program itself, which only exists electronic format. To view this program, insert the CD-ROM (located at the back of this book) into the proper computer drive, open the electronic version of this page, and click the button below; the CASCADE-SEA installation file will open automatically. Follow the prompts on the screen to complete the installation. For more detailed instructions, please refer to the installation guide (also located on the CD-ROM).

Click <u>here</u> to launch the CASCADE-SEA installation program.

Appendix H: Data summaries

The data summaries have been sorted based on the quality criteria found in Table 3.1. Within each of the three main areas (validity, practicality and impact potential), sub-domains have been identified (state of the art knowledge; internal consistency; instrumentality; congruency; cost; better quality materials; and enhances professional development). For each sub-domain, a separate summary has been created for each circuit of activity. Due to the nature of the data, some types could be condensed more than others (e.g.: open interview data was less conducive to summarization than quantifiable questionnaire data). Therefore, it should be noted that the variation in volume (in the data summaries) does not correspond to the amount of data acquired. Rather, these variations are more often due to the nature of the data itself (in particular, whether or not it could be responsibly condensed).

Each of the summaries includes: a brief description of the related circuit's activities; the data sources used in each circuit; those sources used for that particular summary; data weight before activities were conducted and the data weight after the activities took place. Further, data in the summaries were color-coded (better visible in the electronic version) as follows:

- Data relating to the rationale component are teal
- Data relating to the analysis component text are dark green
- Data relating to the design component are blue
- Data relating to the evaluation component are pink
- Data pertaining to more than one area of the program simultaneously or to other parts of the system (not the core components) are dark red
- Data regarding pertaining to potential elements of the program or issues outside of the program are dark grey

Box H.1: Color coding for data summaries

The following table presents an overview of the 187 data summaries created in preparation of the results presented in Chapter 5. Due to practical considerations (documents range from one to five pages in length), these documents are available in electronic format only. To view them, insert the CD-ROM (located at the back of this book) into the proper computer drive, open the electronic version of this page, and click a summary document in the table below; the corresponding file will open automatically (providing Adobe Acrobat Reader™ is installed). Alternatively, visit: Http://projects.edte.utwente.nl/cascade/seastudy/

		Circuit Sequence and Name	Data Weight Overview						
			Validity		*Practicality*			*Impact*	
			SAK	*INC*	*INS*	*CON*	*COS*	*BQM*	EPD
Needs and context analysis	*Literature review & concept validation*	Circuit 1: NL1	SAK1	INC1	INS1	CON1	COS1		
		Circuit 2: AMSTIP	SAK2		INS2	CON2	COS2		
		Circuit 3: TEAMS1	SAK3	INC3	INS3	CON3			
		Circuit 4: SEITT1	SAK4	INC4	INS4	CON4	COS4		
	Site visits (discussion tool)	Circuit 5: SAARMSE	SAK5	INC5	INS5	CON5	COS5		
		Circuit 6: UB	SAK6	INC6	INS6	CON6	COS6		
		Circuit 7: TEAMS2	SAK7	INC7	INS7	CON7	COS7		
Design, development and formative evaluation of prototypes	*Prototype 1*	Circuit 8: DEV1	SAK8	INC8	INS8	CON8	COS8	BQM8	
		Circuit 9: PSU/UGA/USA	SAK9	INC9	INS9	CON9	COS9		
		Circuit 10: NL2	SAK10	INC10	INS10	CON10	COS10		
		Circuit 11: NL3	SAK11	INC11	INS11	CON11	COS11		
	Prototype 2	Circuit 12: DEV2	SAK12	INC12	INS12	CON12	COS12	BQM12	
		Circuit 13: SEITT2	SAK13	INC13	INS13	CON13	COS13		
		Circuit 14: TEAMS3	SAK14	INC14	INS14	CON14	COS14	BQM14	EPD14
	Prototype 3	Circuit 15: DEV3	SAK15	INC15	INS15	CON15	COS15	BQM15	EPD15
		Circuit 16: SW	SAK16	INC16	INS16	CON16	COS16		EPD16
		Circuit 17: UN			INS17	CON17			
		Circuit 18: SEITT3				CON18	COS18		
		Circuit 19: SEITT4	SAK19	INC19	INS19	CON19	COS19	BQM19	EPD19
		Circuit 20: TEAMS4		INC20	INS20	CON20	COS20	BQM20	EPD20
		Circuit 21: UNESCO1	SAK21	INC21	INS21	CON21	COS21	BQM21	EPD21
		Circuit 22: PTLC	SAK22	INC22	INS22	CON22	COS22	BQM22	EPD22
		Circuit 23: RSA1	SAK23	INC23	INS23	CON23	COS23	BQM23	EPD23
		Circuit 24: RSA2	SAK24		INS24	CON24	COS24	BQM24	EPD24
	Prototype 4	Circuit 25: DEV4	SAK25	INC25	INS25	CON25	COS25	BQM25	EPD25
		Circuit 26: NAM	SAK26	INC26	INS26	CON26	COS26		EPD26
		Circuit 27: CET		INC27	INS27	CON27	COS27	BQM27	EPD27
		Circuit 28: SEITT5		INC28	INS28	CON28	COS28	BQM28	EPD28
		Circuit 29: UNESCO2		INC29	INS29	CON29	COS29	BQM29	EPD29
		Circuit 30: SHOMA	SAK30	INC30	INS30	CON30	COS30	BQM30	EPD30
Semi-summative evaluation	*Final evaluation*	Circuit 31: TEAMS5	SAK31	INC31	INS31	CON31	COS31	BQM31	EPD31
		Circuit 32: NL4	SAK32	INC32	INS32	CON32	COS32	BQM32	EPD32
		Circuit 33: NSDSI	SAK33	INC33	INS33	CON33	COS33	BQM33	EPD33
	Query	Circuit 34: QUERY	QUERY34						

Table H.1: Data summaries matrix

Legend
Validity: SAK=state of the art knowledge; INC=internal consistency
Practicality: INS=instrumentality; CON=congruency; COS=cost
Impact: BQM=better quality materials; EPD=enhances professional development

Weight key: = Low = Medium = High = None

Note: The shading in this table represents the data acquired according to the anticipated (albeit evolutionary) data collection plan. Therefore, the weights shown indicate the researcher's anticipated data weight (before activities were carried out). White cells with document names indicate that data were collected in these areas, despite anticipations to the contrary. Grey cells with grey document names indicate the opposite: data were not collected in these areas, despite anticipations to the contrary. Please refer to individual summaries or Table 3.3 for information regarding the data weights as attributed in hindsight (after the activities took place).

Appendix I: Instruments and questions matrix

Phase	Cycle	Circuit	Instrument Code	Research question themes						
				Validity		*Practicality*			*Impact*	
				SAK	*INC*	*INS*	*CON*	*COS*	*BQM*	*EPD*
Analysis	*Concept Validity*	1	D-NL1	•	•	•	•	•		
		2	D-AMSTIP	•						
		3	D-TEAMS1	•		•	•			
		4	DG-SEITT1	•	•	•	•			
	Site visits	5	Q-SAARMSEa	•		•	•	•		
			Q-SAARMSEb				•			
			Q-SAARMSEc			•	•	•		
			DG-SAARMSE	•	•	•	•			
		6	IS-UB	•		•	•			
			DG-UB				•			
		7	IS-TEAMS2	•		•	•			
Design, development and formative evaluation of prototypes	*Prototype 1*	8	W-DEV1	•	•	•	•	•	•	
		9	IS-PSU/UGA/USA	•	•	•	•	•		
			D-PSU	•		•	•			
		10	W-NL2	•	•	•	•	•		
		11	DG-NL3a	•		•	•	•		
			DG-NL3b	•	•	•	•	•		
			DG-NL3c			•	•			
			DG-NL3d	•		•	•	•		
	Prototype 2	12	W-DEV2	•		•	•	•	•	
		13	D-SEITT2	•	•		•	•		
		14	Q-TEAMS3	•	•	•	•	•	•	•
			DG-TEAMS3	•		•	•	•		
			DA-TEAMS3						•	
			O-TEAMS3				•			•
	Prototype 3	15	W-DEV3	•	•	•	•	•	•	•
		16	D-SW	•	•	•	•	•		•
		17	D-UN			•	•			
		18	D-SEITT3				•	•		
		19	IS-SEITT4	•		•	•	•	•	•
			Q-SEITT4a				•			
			Q-SEITT4b	•	•	•	•	•	•	•
			Q-SEITT4c			•	•	•	•	•
			DG-SEITT4	•	•	•	•	•	•	•
			O-SEITT4		•	•	•	•		•
			L-SEITT4	•	•	•	•	•		
			DA-SEITT4		•	•	•		•	
		20	IS-TEAMS4		•		•			
			Q-TEAMS4a				•			
			Q-TEAMS4b			•	•	•		
			Q-TEAMS4c			•	•	•		
			Q-TEAMS4d			•	•	•		
			Q-TEAMS4e			•	•	•		
			O-TEAMS4		•	•	•	•		
			DA-TEAMS4						•	
		21	IS-UNESCO1	•		•	•		•	•
			Q-UNESCO1a				•			
			Q-UNESCO1b	•	•	•	•			
			DG-UNESCO1	•		•	•	•		•
			O-UNESCO1			•	•			•
			L-UNESCO1			•	•			
			DA-UNESCO1						•	

Table I.1: Instruments and questions matrix (continued on next page)

Phase	Cycle	Circuit	Instrument Code	Research question themes						
				Validity		*Practicality*			*Impact*	
				SAK	*INC*	*INS*	*CON*	*COS*	*BQM*	*EPD*
Design, development and formative evaluation of prototypes	*Prototype 3*	22	IS-PTLC			•	•	•	•	
			Q-PTLCa			•	•			
			Q-PTLCb			•	•	•	•	
			Q-PTLCc				•	•	•	
			Q-PTLCd				•			
			Q-PTLCe				•			
			O-PTLC			•	•	•	•	
			DG-PTLC			•	•	•	•	
		23	Q-RSA1a				•			
			Q-RSA1b	•	•	•	•	•		
			Q-RSA1c	•	•	•	•	•	•	•
			DG-RSA1		•	•	•	•	•	
			O-RSA1			•	•			
			L-RSA1	•		•	•	•		
		24	Q-RSA2	•		•	•	•	•	•
			DG-RSA2	•		•	•			•
	Prototype 4	25	W-DEV4	•	•	•	•	•		
		26	Q-NAM				•	•		•
			DG-NAM	•		•	•	•		•
		27	Q-CETa			•	•	•	•	•
			Q-CETb			•	•	•		•
			DG-CET				•			•
			O-CET				•			
		28	Q-SEITT5a		•	•	•	•	•	•
			Q-SEITT5b			•	•	•	•	•
			O-SEITT5			•	•			•
			DG-SEITT5			•	•			
		29	Q-UNESCO2				•	•	•	•
			DG-UNESCO2				•		•	•
			O-UNESCO2?							•
			L-UNESCO2				•			
		30	IS-SHOMAa-c			•	•	•	•	•
			Q-SHOMAa				•			
			Q-SHOMAb	•		•	•	•	•	•
			Q-SHOMAc			•	•			
			Q-SHOMAd			•				
			O-SHOMAa-b							•
			DA-SHOMA						•	
Semi-summative evaluation	*Final evaluation*	31	Q-TEAMS5a					•	•	•
			Q-TEAMS5b				•			
			DG-TEAMS5				•	•		•
			O-TEAMS5			•		•		
			DA-TEAMS5						•	
		32	Q- NL3	•	•	•			•	•
			DG- NL3	•	•	•	•	•	•	•
			O-NL3			•				
			DA-NL3	•	•	•	•	•	•	•
		33	Q-NSDSI							•
			DG-NSDSI			•	•	•	•	•
			O-NSDSI		•	•			•	•
			L-NSDSI	•		•	•	•	•	•
			DA-NSDSI	•		•	•	•	•	•
		34	Q-QUERY	The query touched on each of these aspects, but also explored other areas						

Table I.1: Instruments and questions matrix

Legend • = instrument yielded information regarding the associated theme

Validity: SAK=state of the art knowledge; INC=internal consistency

Practicality: INS=instrumentality; CON=congruency; COS=cost

Impact: BQM=better quality materials; EPD=enhances professional development

Appendix J: Sample Plans

This appendix contains samples of exemplary lesson plans made with prototype two of the CASCADE-SEA program (the Lesson Builder) during the week-long writer's workshop in Circuit 14 (TEAMS3). Due to practical considerations, these documents are available in electronic format only. To view them, insert the CD-ROM (located at the back of this book) into the proper computer drive, open the electronic version of this page, and click an item name in the table below. The corresponding file will open automatically (these appendices require that Adobe Acrobat Reader™ be installed).

Item name	**Plan title**
Appendix J-1	Mendelian inheritance
Appendix J-2	Acid-base titration
Appendix J-3	Endothermic and exothermic reactions

Box J.1: Sample plans

Appendix K: Query Package

This appendix contains relevant components of the query package and a synopsis of the findings with regard to the future of the CASCADE-SEA line of inquiry. (For additional detail, please refer to data summary document QUERY34, available via Appendix H.) Due to practical considerations (this package centered around its CD-ROM), the package elements are available in electronic format only. To view them, insert the CD-ROM (located at the back of this book) into the proper computer drive, open the electronic version of this page, and click an item name in the table below. The corresponding file will open automatically (Appendices K-1 - K-3 require that Adobe Acrobat Reader™ be installed).

Item name	Brief description
Appendix K-1	Cover letter: brief (one-page) letter to the participant explaining how to complete the query (originally termed survey)
Appendix K-2	Installation instructions: an instruction sheet for installing the CASCADE-SEA program
Appendix K-3	Query questionnaire: a printed copy of the query questionnaire (Q-QUERY) and
Appendix K-4	About CASCADE-SEA: a program (on the query CD-ROM) that offers background information about the CASCADE-SEA program and research

Box K.1: Query package

Synopsis of findings with regard to the future of CASCADE-SEA

The query (originally termed survey) questionnaire explained that the CASCADE-SEA program is freely available, but that implementing it may still require investments in terms of time, human resources, computers and so on. Then, it asked participants to consider whether they/their organization might be interested in working with CASCADE-SEA (or a version thereof) in two ways: in an *ideal* situation (where financial resources were not concern); and in the participant's *genuine* situation (with real-world resources and limitations in mind). In each case, participants who indicated that they (or their organization) would be interested in using CASCADE-SEA, were also asked to indicate what kind(s) of activities they would like to see take place in terms of using the program (or a version thereof).

Of the 34 participants, 29 answered the question regarding their ideal situation and 21 answered the question concerning their genuine situation; these responses are summarized in Box K.2 (next page). As this box illustrates, most participants were interested in using CASCADE-SEA, although the amount interested in using CASCADE-SEA in their genuine situation was lower when compared to those interested in using it in an ideal situation.

Interest in working with CASCADE-SEA	Yes	No
Ideal situation	24	5
Genuine situation	11	10

Box K.2: Interest in CASCADE-SEA

Five participants chose to include an explanation of why their answers changed from yes to no (written in the margin); three of them indicated that it was due to a lack of computing facilities and two of them stated that their own responsibilities are too far removed from that which is supported by CASCADE-SEA.

Participants indicating that they (or their organization) would be interested in using CASCADE-SEA described activities that would be desirable in terms of their ideal and genuine situations. These activities fell into three main areas:

- *Customization* of the tool (for local settings);
- *Professional development* of various (potential) user groups;
- *Implementation* of CASCADE-SEA (toward varying goals).

With regard to customization of the tool, participant recommendations pertained primarily to language and content. For both the ideal and the genuine situations, participants said that they would like to (help) translate the program into local languages (e.g. Thai and Hindi). Concerning the content, participant reactions were again similar for both ideal and genuinely in situations. They wanted CASCADE-SEA to address other subject areas (e.g. language arts, reading and philosophy); further, they wanted the program to help users design standards-based materials.

In terms of using CASCADE-SEA in the professional development of various (potential) user groups, participants mentioned quite a variety: preservice teachers, inservice teachers, teacher trainers, graduate students, university lecturers. This list remained the same for both ideal and genuine situations in terms of groups mentioned; however, the volume (number of times mentioned) did decrease.

Finally, related to the user groups, participants described the ways they felt CASCADE-SEA could be meaningfully implemented in their own (ideal and genuine) situations. They indicated that they felt CASCADE-SEA should be used toward facilitating growth/understanding in the following areas: computer literacy (as a practice tool); macro-level curriculum development (e.g. with staff in areas with little formal tradition in systematic design); interactive educational media (as an example); curriculum and instruction (as a model/tool); classroom action research (as a model/tool); materials design (as a resource for teachers and developers); and as an example of a way to pursue curriculum improvement in developing countries (as a case study). Additionally, one participant also mentioned the notion of using CASCADE-SEA to help facilitate policy-maker communication; however, this was only mentioned in the ideal situation, not the genuine one.

Indices

Index A: Visuals

Figures

Tables

Boxes

Index B: Glossary

A-level	Advanced-level (Cambridge syllabus)
AMSTIP	This group was composed of individuals from the Accelerated Mathematics and Science Teacher Improvement Program
BQM	Better Quality Materials
CASCADE	Computer ASsisted Curriculum Analysis, Design and Evaluation
CASCADE-SEA	Computer ASsisted Curriculum Analysis, Design and Evaluation for Science Education in Africa
CD-ROM	Compact Disk - Read Only Memory
CET	This group contained graduate students (practicing teachers) participating in course work at the Center for Education Technology at the University of Zimbabwe
CIA	Central Intelligence Agency (see references)
CON	Congruence
COS	Cost
CSCD	Computer Supported Curriculum Development
DECIDE	Dutch Expertise Center for International Development in Education
DEV	This Developer group consisted of one primary researcher/developer and three mentors
EPD	Enhances Professional Development
EPSS	Electronic Performance Support System
ICT	Information and Communications Technologies
INC	INternal Consistency
INS	INStrumentality
NAM	This group consisted of staff from the Ministry of Basic Education and Culture, the National Institute for Educational Development and The Presidential High Commission on Eduction, Culture and Training who attended the workshop organized by the NAMibian Human Resources Development program
NL	This group was comprised of Dutch (NL) experts
NSDSI	This group represents the participants in the Namibian School Development and School Improvement Program
PSU/UGA/USA	This group represents experts from Penn State University, University of Georgia and the University of South Alabama
PTLC	This group pertains to teachers who attended workshops at the Ponhofi Teaching and Learning Center
QUERY	This group participated in the exploratory query
RSA	This group was involved in research activities in the Republic of South Africa

SAARMSE	This group participated in the Southern African Association for Research in Science and Mathematics Education conference workshop in Johannesburg
SAK	State of the art knowledge
SEITT	This group participated in activities organized in collaboration with the Science Education Inservice Teaher Training program in Zimbabwe
SHOMA	This group participated in workshop activities organized in cooperation with Shoma, an educational foundation in South Africa
SLO	Specialisten in Leerplan Ontwikkeling (Dutch Institute for Curriculum Development)
SW	This group contains the hands-on session participants from the Developing Teacher Leadership for Curriculum Innovation in Science and Mathematics workshop in Swaziland
TEAMS	This group refers to those associated with the Tanzanian Teacher Education Assistance in Mathematics and Science Education program
TRC	Teacher Resource Center
UB (INSET)	This group refers to those participants affiliated with the University of Botswana INService Education Training program for science and mathematics teachers
UN	This group contains University of Natal staff working at the Institute for Partnerships between Education and Business
UNESCO	This group refers to the staff and students invloved in UNESCO's Creating Learning Networks for African Teachers program (Learning Without Frontiers)
UT	University of Twente
VUA	Vrije Universiteit Amsterdam

Index C: Keywords

The research described in this book was initiated to explore the potential of the computer to support curriculum materials development within the context of secondary level science and mathematics education in southern Africa. During the course of the study, a computer program was developed named CASCADE-SEA, which stands for Computer Assisted Curriculum Analysis, Design and Evaluation for Science (and mathematics) Education in Africa. By carefully documenting the iterative process of analysis, prototype design, evaluation and revision, insights were sought with regard to the characteristics of a valid and practical computer-based tool that possesses the potential to impact the performance of its users. The results of this study include the CASCADE-SEA program itself (located on the CD-ROM inside the back cover of this book) which assists users in producing better quality materials than they otherwise might, while learning from the development process. Further, this research has contributed to the articulation of design principles and related development research methods.

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