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In the Classroom

# Keller's "Old" Personalized System of Instruction: A "New" Solution for Today's College Chemistry Students

**MARK S. CRACOLICE** and **STEPHEN M. ROTH**
The University of Montana
Missoula, MT 59812, USA
MarkC@selway.UMT.edu

*Why is this system, designed to improve learning and retention, falling into the ranks of "educational history"?*

This article examines a long-dormant teaching methodology known as the Personalized System of Instruction (PSI). The literature documenting the effectiveness of PSI is reviewed, showing that it is superior to traditional instruction. Even given this evidence, few educators employ this instructional strategy today. Arguments against PSI are examined, and suggestions are made on how to avoid the pitfalls associated with PSI. The article also discusses how to implement PSI in a college chemistry course.

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What would you do if you discovered an instructional strategy that raised the scores of your students from the 50th percentile to the 70th percentile? What if that strategy required more work on your part the first time you taught the course? Would it be worth the effort? Such a strategy has been known for more than 25 years, yet it is virtually ignored. We will describe the PSI

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format and its successes, discuss the problems that led to its demise, and demonstrate that PSI provides an effective tool for college chemistry instruction.

In 1968, Fred Keller first published a revolutionary plan for college instruction called the Personalized System of Instruction, or PSI. Soon after, the educational world was active with research and commentary on this self-paced, mastery-oriented format. Programs all over the world adopted PSI into various courses, and personalized instruction was viewed as the format of the future. The momentum of the educational establishment and the inertia of lecture-oriented instruction, however, began to slow the pace of implementation of the Keller Plan. By the early 1980s, the number of research articles began to diminish, and it became evident that PSI was not going to replace the lecture format. What is happening to PSI? Why is this system, designed to improve learning and retention, falling into the ranks of "educational history"? Before answering this question, let's first examine PSI and its effectiveness as an instructional method.

## PSI: The Plan and its Effectiveness

Keller's Personalized System of Instruction is based on individualized instruction [1]. The plan has five major components: 1. A self-paced feature that allows students of differing entry levels and abilities to learn at their own rate. 2. A mastery requirement that allows students to continue only after the mastery of previous material has been demonstrated. 3. The utilization of peer proctors for immediate scoring, feedback, tutoring and support. 4. The minimal use, if any, of lectures. (Keller felt that large group instruction was adequate for only a small fraction of the student population and that individualized instruction was the most effective method for successful learning.) 5. The use of texts and study guides for the communication of course materials.

In other words, the students attend class the first day and leave with an outline of all the material the instructor feels should be mastered for course completion. After initial instruction, the students proceed individually through the instructional units at their own pace, spending less time with what they perceive as easier units and extra time with more challenging material. When finished with a unit (i.e., having completed the text and study guide assignment), a student returns to a designated classroom and requests a test on that unit. A student who passes the test with mastery is able to proceed to the next unit. A student who does not pass the test is not penalized as in a traditional format, but is given verbal tutoring as immediate feedback from the proctor and shown specific

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areas of the text and study guide where problems may be overcome. After restudying the unit, the student retests over the same material, and the cycle repeats itself until that student has completed all course units with mastery. In Keller's original format grades were not given and no time period was allotted for completion. Keller felt that mastery is the goal of teaching and that such mastery should not be confined to a certain time period. With complete mastery of the course material, implicit in PSI, the use of grades becomes obsolete.

In order to be successful within most present educational formats, Keller's original system requires alteration. Grades are necessary and unlimited time is difficult to organize, so the majority of PSI courses undergo modification. The original ideals of the system are retained, but additional steps are taken to conform to the established system. Often, final exams and midterms are added to better evaluate the student's progress, and review units or review quiz components are used to increase retention [2], [3]. The course is generally designed to fit within the confines of a quarter or semester, with the number of units to be completed is similar to the material originally designed for lecture dissemination [4]. Even with these many changes, PSI can still be a successful instructional strategy.

From the onset of Keller's first PSI class, PSI has proven to be a successful format for college instruction [5], [6], [7], [8]. Interest peaked from 1972–1979, but was followed by a steady decline [9]. Figure 1 shows the number of PSI articles published over the period 1969–1994 in the *Journal of Chemical Education*, the primary source of published articles on chemistry and PSI during this time period. The majority of these articles showed that the effectiveness of PSI was greater than that of conventional instruction for one or more evaluation criteria. In 1990, Kulik, Kulik, and Bangert-Downs [7] summarized the primary literature by publishing a meta-analysis of mastery learning; they found that exam performance, retention, student evaluations and attitudes were all superior to traditional course formats. While rates of course completion were not always higher in PSI courses, exam score results were consistently superior in PSI courses with both low and high rates of completion. They also found that students spent slightly more time studying in PSI courses, but the data suggested that the exam score increases did not result from increases in instructional time alone.

PSI and mastery learning have been shown to produce higher levels of learning and retention, and PSI students have more confidence in their correct responses than students in conventional courses [10], [11]. The opportunities for additional practice in PSI may

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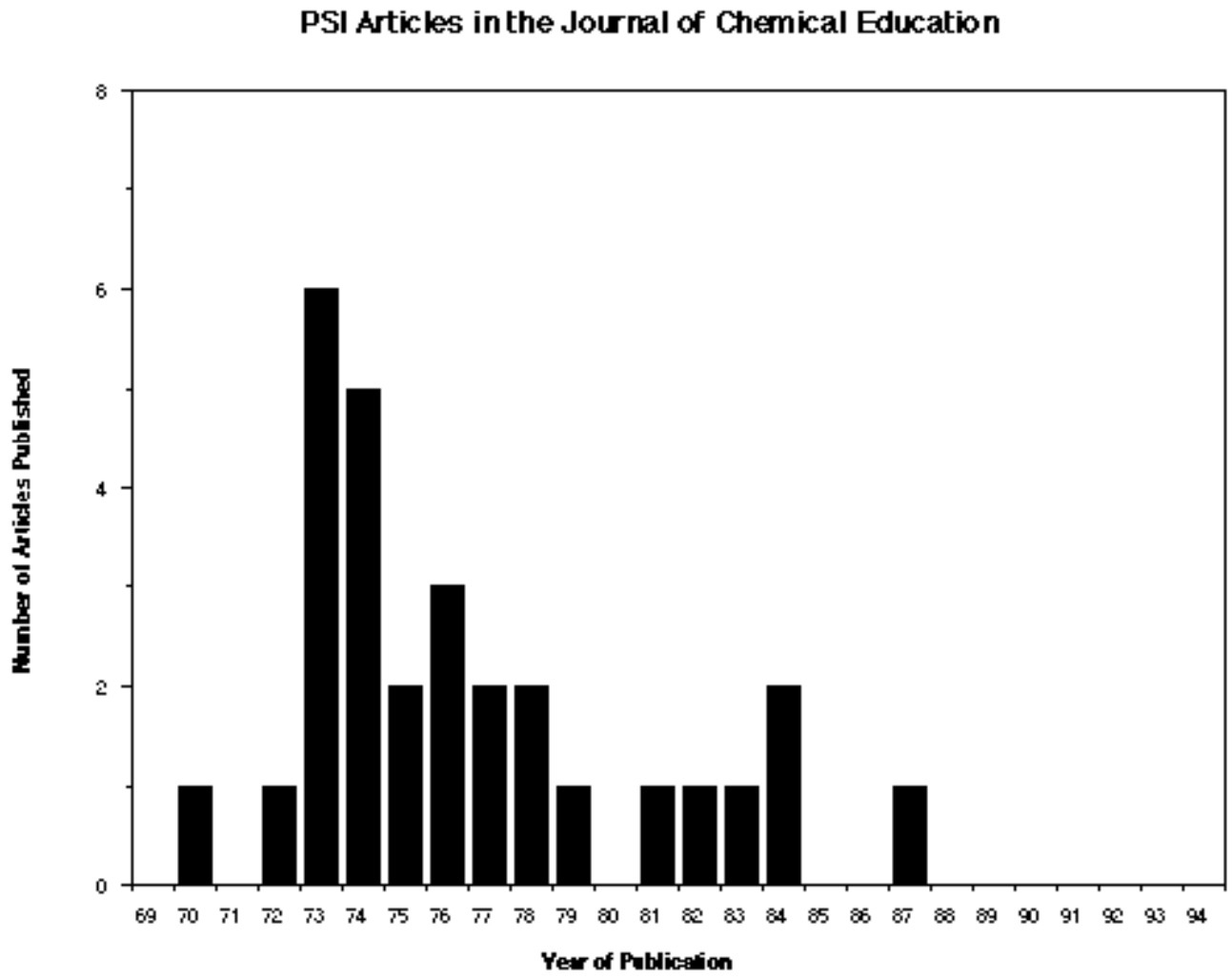


**FIGURE 1.** NUMBER OF PSI ARTICLES PUBLISHED ANNUALLY IN THE JOURNAL OF CHEMICAL EDUCATION OVER THE PERIOD 1969–1994.

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result in certain areas being overlearned and thus less susceptible to forgetting [11]. Additionally, studies have shown that students evaluate PSI courses higher, and they have more favorable attitudes toward the courses [6], [7]. Instructors themselves also have better attitudes when teaching PSI courses [12], [13]. These favorable attitudes emerge even though students and instructors work harder than in conventional courses [14]. Although PSI was first designed for and used in a psychology course, its use spread to a variety of other disciplines, including chemistry, with similar success [15], [16], [17], [18]. It has been found that PSI works best for foundational courses where the content is easily adapted to units designed around basic objectives [19], [20], [21]. Given the PSI emphasis on small instructional units, studies suggest that the performance successes of students with historically poor academic records are rarely different from those with superior academic records [7], [22]. PSI's individualized learning format seems to shrink the lower-division course "entry gap" based on a student's previous experience, so often found in the traditional classroom [23], [24], and particularly found in introductory college chemistry.

## The Disappearance of PSI

If PSI is a superior instructional format, why is it not still popular today? A 1986 study showed that only 23 of the 43 surveyed past users were still using PSI [25]. In peak years, many articles not only extolled the benefits of PSI, but also complained about certain aspects of the system. Probably the predominant complaint was the changing role of the instructor in a PSI course. The instructor becomes a "facilitator of learning" in a PSI course [1], whose main role is the coordination and organization of the text and study guides needed for student success. Along with this changing role, the initial workload in a first-year PSI course can be intense [14]. The choosing of an adequate text and the formation of the study guides, not to mention the unit tests and final exams, are daunting tasks for even the most experienced instructor [14]. Along with the large number of tests comes the administrative difficulties of charting the students' progress throughout the term. These problems, inherent in PSI, are not the only reasons for its demise in the educational world.

Other major reasons for PSI's failure to thrive are found in the self-preservational nature of the educational establishment [26], [27]. The inertia of the lecture system stifles the potential growth of this instructional strategy, as instructors are often praised for their lecturing ability, and additionally, they are subjected to peer review based on their in-class presentations [13], [26], [28]. Moreover, a rigid tenure system [28], [29] and a

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corresponding de facto lack of academic freedom for untenured instructors [30] adds to the obstacles PSI has to overcome. Additionally, lecture is kept because of its occasional successes and its convenience for the instructor [26]. These various obstacles reduced the fast-growing beginnings of PSI to the lack of interest we see today. Is the demise of this proven instructional system justified by these complaints?

## Examining the Problems with PSI

*Instructor Workload and Role in PSI*

Keller's major argument with the lecture format was that students learn by doing on an individual basis, and, even in the most open classrooms, average students will fail to master material in a group setting [1]. Thus, the instructor's role would have to change dramatically [1], [27]. Some instructors felt the move from lecturer to "manager of instruction" was a reduced role, placing them in a more technical rather than a professional field [31], [32]. Additionally, PSI instructors work harder than ever, and the summer prior to beginning a PSI course can be a strenuous time of material organization and proctor training [5], [14], [26], [33], [34]. Silberman felt the yearly updating of course material and the charting of student progress were tedious and time consuming activities [33]. For course success, PSI requires more personal interaction between student and instructor than does the lecture method [3], [35], [36]. Overall, many instructors were dissatisfied with their removal from the lecture spotlight and the increased workload required when the PSI course was first implemented.

These problems with the changing role and increased workload have been addressed and answered in the literature. First, *over the long term*, the PSI course workload appears to be equal to that required for traditional lecture-based courses [34], and with short cuts such as computer utilization and reusable test banks, PSI can be even more efficient than many other instructional formats [3]. Although the initial workload is difficult, with time, a PSI course is no more demanding than a conventional course. After the first year of PSI implementation, some departments have seen an overall reduction in faculty workload because one PSI instructor can supervise two or three sections of a traditional class [3]. Silberman found that a computerized quiz generator helped ease the instructor's time demands [33], and these quiz generators are now available from every major textbook publisher. Instructing proctors to record test grades immediately following a testing session will also ease the administrative burden. PSI allows a class to be tailored to every student at all entry levels [20], [34], [37]. This allows the best students

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to speed through the material they already know, while the inexperienced pace themselves according to their individual needs, thus easing the instructor workload, partially because the better students finish before the end of the term [1].

Additionally, PSI frees the instructor from teaching the mundane and repetitious, so time can be better utilized for more creative instruction directly with the students [14]. Although the role of the instructor changes from "the wizard on the stage" to an instructional manager who is visible only on an individual basis, many instructors find that working with students one-on-one can be more satisfying than lecturing. Students appreciate this role also, as studies indicate that they prefer active instructors who become involved in the individual learning process [38], [39]. An additional reason that PSI is superior to other forms of instruction is that the instructor is immediately available for answering questions, adding artistry, and treating unique ideas not covered in the text [14]. PSI can also be modified to fit within almost any other instructional framework such as small group work or cooperative learning.

*Student Procrastination and Withdrawal in PSI*

Some studies indicate that student withdrawal and procrastination are the major problems in a PSI course [40]. There are mixed results in the literature about the withdrawal rates of students in PSI courses. In Kulik, Kulik, and Bangert-Downs' review, no significant difference was found in the rates of withdrawal in PSI compared to conventional classes [7]. The complaint may, nonetheless, be well founded with a number of studies showing higher rates of withdrawal as well as problems with procrastination [41], [42].

Many studies have examined these problems, and a variety of explanations have been offered to justify the higher withdrawal levels in a PSI course. Many instructors who teach using PSI consider the higher withdrawal rates acceptable because they are due to the students who resist working at a mastery level and/or procrastinate early in the course [24], [42], [43]. The initial course outline and newness of the PSI format may be enough to intimidate students. Some students have difficulty pacing themselves and procedures designed to help these students at the beginning of the term may keep them from withdrawing [42], [44]. The time management skills required in a PSI course are also difficult for some students. Although Kulik, Kulik, and Bangert-Downs found only a 4% increase in student workload [7], Arlin reported up to a 40% increase in study time compared to a traditional course [45]. Additionally, if a student does not have the basic

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reading or math skills to complete the first few units, withdrawal is a likely option, as students in PSI can make rational decisions about their own progress and abilities for success [34]. It appears that the potential for an increase in withdrawal rates in a PSI course is justified because a PSI course simply forces students to realize their deficiency earlier in the term.

Some students who stay in a PSI course have problems with procrastination. A number of studies have examined the problem, and there are many strategies that help students progress at a steady pace throughout the course with increases in exam performance compared to students in courses that do not employ pacing strategies [43], [46], [47], [48], [49]. Daily quizzes, instructor pacing, student contracts, and penalty deadlines have all been employed to increase student performance while decreasing procrastination [43], [47], [48], [49]. It has also been found that procrastination can be prevented by publishing a list of recommended completion dates for the units, making entry into motivational lectures contingent on passing certain units and offering early final exams for those students who complete the units early in the term [46].

*Degree of Learning and Content in PSI*

Some questions and complaints concerning PSI's effectiveness are less concrete. Do PSI students learn the same amount as students in a traditional course [50], [51]? Is the narrow mastery of some units being substituted for a broader perspective that leads to understanding and creative use of knowledge [32]? Can PSI be applied to courses where higher order cognitive thinking is required? Mellon argued that there is more to the college experience than simply learning skills [52]. Slavin indicated that PSI instructors are held to the objectives established at the onset of course, whereas conventional instructors can teach material that is useful or important but is not assessed on the final test [53]. If the objectives stated are too narrow, or the level of mastery is reduced below 90%, then low-level content can be a problem in PSI [14], [51], [54].

Research clearly indicates that the fear of lack of content in a PSI course when compared to a traditional course is unfounded. Kulik, Kulik, and Carmichael found that degree of content learned in PSI *always* equals, and often exceeds, learning under conventional methods [46]. Lewis and Wolf explained that PSI students are learning more and less at the same time, with students learning more of the most important material in a PSI course. They also indicated that mastery of most concepts, with little or no exposure to a few

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others, is preferable to a hazy overview of everything [55]. In this way mastery learning simultaneously increases the level of achievement while decreasing the variability [50]. Caldwell indicated that applying behavioral objectives can raise the level of course content [51], and Bent felt that, most importantly, the students believe they have learned more in a PSI course [13].

Some departments, after instituting PSI in introductory courses, found a dramatic increase in the number of majors in their field the following year, which suggests that PSI enlightens the student on a personal level [30]. A study by Reboy and Semb showed PSI has been used in courses where higher order cognitive skills are needed, and, in addition, they noted that PSI helps increase a student's higher order cognitive skills [56]. Semb and Ellis also indicated that PSI and mastery learning can be used to produce higher levels of original learning and retention [10]. Finally, Reboy and Semb point out that PSI is an instructional delivery system that does not restrict a course's content [56]. So courses requiring higher order thinking need only a creative instructor who can develop the behavioral objectives needed for student success.

*Proctors in PSI*

The utilization of proctors in PSI has come under scrutiny. Lippencott questioned whether it was wise to have student tutors determine when other students have mastered a unit of study [32]. Can a peer proctor be trusted to adequately evaluate a peer PSI student [51]? Can proctors consistently grade quizzes [8]? Will students attempt to manipulate the proctor for their own benefit [51]?

Keller felt that proctors were a key aspect of the course and that PSI could not be successful without them [1]. With the workload involved, they are definitely an intricate part of the format. Overall, the use of proctors has been shown to be a successful and necessary format for the immediate feedback of students [57], [58], which is a crucial element of PSI's effectiveness [17]. Before the course even begins, Lewis and Wolf advise instructors to choose proctors carefully in order to develop a trusting relationship early on [55]. Some studies have shown that proctors can be replaced with reliable computer tutorials with no detriment to student performance or attitude [59], [60]. To eliminate some problems, Bent felt that instructors, rather than proctors, should evaluate students [13]. Additionally, Caldwell argued that proctors should be assigned changing roles such that relationships leading to course corruption are less likely to develop. Caldwell also indicated that an

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emphasis on final exam scores would decrease reliance on quiz grades and would, thus, ease the potential for proctor corruptibility [51]. Regardless of strategy, the instructor must keep in close contact with the proctors and the students, if for no other reason than to provide a sense of authority and example [3].

Some feel that student proctors benefit the most from a PSI format because of their introduction to teaching and the requirement for complete knowledge of the subject [10], [33]. Semb and Ellis found proctors in PSI have substantial retention of course material, a benefit for the proctors themselves in their later courses [10]. Students will often ask questions of a peer proctor that they would not ask of an instructor, and the proctors learn a great deal of chemistry when they think about and answer these questions.

*Grades in PSI*

The normal grade distribution found in a traditional course is generally turned upside-down in a PSI format [1]. The mastery component generally leads to two possibilities: 1. the student completes the requirements of the course and receives an “A” or a “B”, or 2. the student fails to meet the requirements and fails the course or receives an incomplete. What occurs generally is a “U” shaped distribution that must be justified. This may be one of the most difficult aspects of a successful PSI course [3], [35]. Many times, studies show that a large majority of the students receive “As” in PSI courses [7]. Justification of a large number of “As” and “Bs” to department chairs and college deans can be a problem.

Keller’s original plan was designed along with an abolishment of the grading system all together. Because this idea is not an acceptable alternative in today’s educational system, grades in PSI courses must be justified using comparisons to the traditional lecture method. Bent felt that his final grades were higher because students in his PSI course worked harder, and he indicated that PSI grades measure achievement rather than IQ [13]. Without a final exam, the distribution of grades is difficult to justify, and such exams are often suggested to enhance the grading process [3]. Showing colleagues final exam comparisons from previous years and explaining that the students have mastered the same course material covered in the previous lecture courses will help ease concerns that the course was easy. Some researchers have employed grading schemes designed to form the “normal” curve [35], but is it good that the majority of students move on to advanced courses without complete mastery of the material they are required to know, as in conventional instruction [14], [20]? Instructors who implement the PSI format generally find that their students

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perform at a higher level than in a traditional course and thus deserve better grades.

*Behaviorism Versus Cognitivism*

PSI can be criticized as an instructional strategy because of its roots in behavioral psychology. Behavorial learning is based on reinforcement of desired behavior and punishment for inappropriate behavior. Behaviorism can be criticized because it relies only upon directly measurable, observable behavior, and it does not consider the cognitive processing that produces the behaviors. The current dominant paradigm in science education is cognitive psychology, with an emphasis on the constructivist view of learning. Constructivism is a general term derived from a group of philosophical and psychological theories, which stress that learners actively construct knowledge through their interactions with the enviroment. To summarize constructivism, Bodner stated, "Knowledge is constructed in the mind of the learner," and he argued that a constructivist model for teaching implies that the role of the instructor is that of a learning facilitator who listens to students [61]. Wolke argued that the differences between training and education need to be considered, and a behaviorist approach emphasizes training rather than a true education, which includes synthesis, transfer of training, and emotional content, among other skills [62].

A two-way dialogue between student and teacher is exactly what occurs in PSI, and thus a PSI-formatted course actually may be considered to fit the constructivist model. A strength of PSI is that the proctors tutor the students on an individual basis, and one-on-one tutoring is clearly the most effective method of teaching [63]. The student is constantly interacting with the proctors, which as Keller says, results in "almost unavoidable tutoring and a marked enhancement of the personal-social aspect of the educational process" [1]. Additionally, recent neuropsychological evidence indicates that the behaviorism versus cognitivism debate may be invalid because learning occurs through both mechanisms, and thus research that supports both the behavioristic and cognitivistic models is justified [64].

*Lack of Lectures in PSI*

The provision of not using lectures to disseminate information is a difficult concept for many habitual lecturers [65]. If an instructor is an excellent lecturer, should that skill be hidden behind a "manager of instruction" title? Further, some have questioned whether

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textbooks and study guides can adequately "replace" an instructor [32]. The point can easily be argued that lecture is a beneficial learning tool for some students [52], [55]. Upon finishing a PSI course, some students suggest the use of *some* lectures for the dissemination of difficult or confusing material. Utilizing lectures to enhance the information given in the study guides and the text could clear up conceptual difficulties, especially for slower students [66].

Because the majority of students do not learn well in a lecture format, Keller originally used occasional lectures for their sermon-like properties to promote student motivation [1]. The text and study guide were to convey the course material with the study guide clarifying uneven parts of the text and containing the opinions of the instructor on specific points to promote student interest and introduce the intricacies of the subject [14]. The inertia of lecture is maintained by its occasional success [26], and if lecture is something that can benefit students then it should be kept in place [66]. But those students who do not learn well in the lecture format must not be penalized. If the instructor uses lecture to convey information, then that information should be provided in another form for those who do not learn most effectively in the lecture format [34]. Bent used two lectures per week to ease students into PSI slowly, develop a sense of community, introduce new material, and discuss confusing topics [13]. Some instructors use lectures for demonstrations or explanations of poorly written sections of the text [13], [67]. We agree with others that lectures should supplement the PSI format [52], [55]. By lecturing over information that is based on the original objectives as stated at the beginning of the term, the students and the instructor will benefit from this modification of the original PSI format.

## Conclusion

The complaints about and problems with PSI can be solved with a little work and creativity without significantly decreasing the benefits to students of the original format. As stated earlier, PSI has been shown to raise student exam scores, increase retention, and improve attitudes and course evaluations when compared to the lecture format. Of all the educational technologies designed in the past few decades, PSI is considered one of the most useful and successful formats developed, and it is especially successful in foundational chemistry courses.

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## Implementation of a Chemistry PSI Course

Many articles provide plans and suggestions for the implementation of a PSI course, as well as cautions. We've taken the most critical and included them in this article, and we encourage the reading of the articles referenced. A brief description of our experience in implementing and developing a PSI-formatted preparatory chemistry course follows, along with some suggestions.

1. Start slowly. A PSI course can gradually be developed from a traditional lecture course; it does not have to be an all-or-nothing approach. The unit assignments and learning objectives can be gradually developed over many terms. As PSI units are developed, they can implemented as partial substitutes for the lecture-based course until the complete PSI course is finished.

2. Choose a "readable" and understandable text. This is the most critical element to starting a PSI course as this will be the basis for the course. In adopting a text for the course, use a critical eye with respect to whether the text will stand alone without support from a lecture. The choice or development of a study guide is also essential to implementation of the PSI instructional strategy. The study guide should clearly outline the unit assignments and the learning objectives related to the assignments.

3. Separate the text material into units, the smaller the better. We designed three similar tests for each of these units. Smaller units are preferable to larger units, but the smaller the units of study, the greater the administrative load. Readily available technology can make the task easier. Computers are useful for generating large banks of quiz questions that can be revised and stored for later use. We partially relied on the computerized test bank supplied by the textbook publisher as a source of questions. We separated our course into 40 units, including ten review units designed to enhance retention of course material. Each chapter of the text was divided into approximately three units, depending on the content, and at the end of each chapter, we administered a comprehensive unit test that contained approximately half questions from the immediately preceding chapter and half questions from the earlier material. This gives our course a continual review component.

4. Elaborately define the course in syllabus form. We set up a series of "recommended dates" for passing unit tests which were evenly spaced throughout the semester so that a student who follows them will complete the course at the end of the semester. One week after the recommended date is the "penalty date", where the requirements for each grade

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on the final examination are raised by 1%. Two weeks following the recommended date is the "deadline date", where grade requirements are raised by 2.5% and the student moves on to the next unit, even though the preceeding unit has not been mastered. Students, however, are responsible for all units not passed, as the subject matter will appear in subsequent review questions and the final examination is comprehensive. Students are allowed to move through the course as quickly as possible, and early completion is encouraged.

The course grade is dependent on performance on the final exam, subject to penalties for failure to complete the unit test requirements as described above. We feel that this reduces the pressure on the proctors, and with our continual review component, it is a fair assessment of a student's performance.

5. Carefully choose and train proctors. They must know the material and be able to evaluate the students' progress. They also must be able to provide feedback and motivation. At the beginning of the semester, the instructor in charge of the course works closely with the proctors, helping them interact with the students. As the semester progresses, the supervision of the proctors is reduced. The proctors are instructed to refer the student to the instructor under any non-routine circumstance. We have had success with one student proctor available approximately 15 hours per week per 25 students.

6. Keep the format flexible. We suggest that you make the course as simple as possible and prepare for as many objections and student complaints as possible. For example, we have eliminated units from the original course design, changed the format of the exams, modified the grading criteria, and altered the sequencing of topics from our original course. In particular, we have had more success with more frequent, smaller unit tests instead of our original one unit test per chapter design.

7. Continue to rely on the advice of colleagues. In other words, we often find solutions to our problems in the literature. With the research done in the 1970s and 1980s, suggestions for PSI are many. We reread Keller's original article frequently. With each new term, we begin our changes for the next term within the first week of the course. Interested readers may contact the senior author for copies of our course materials.

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*A Student Testimonial*

PSI courses have the ability to make students take responsibility for their own learning, and we are finding that our students learn much more than chemistry. Here is one student's end-of-semester anonymous course evaluation:

> I really like the way this class was structured. It made me take responsibility for my own grades. I know that this is the first college class that I will not have to cram for. I have already studied and learned everything. As I said, this is a great class and it has changed the way that I do things. I now actually study during the week, even when I don't have any tests, and it has carried over to my other classes. This will be my best semester here yet.

## PSI and Education Today

PSI is a system proven to increase grades and learning, not through grade inflation, but through hard work and increased educational efficiency. PSI forces students to take responsibility for their education. Under the PSI format, students perform better and retain more information than their traditional student counterparts. Overall, students and instructors also like PSI courses more than traditional courses. With the continuing changes in the nature of the student population, chemistry instructors must be open to "new" solutions to educational problems, and they must be aware of the "old" solutions that are already proven to work. Given that the goal of the college or university is the education of the student and not the preservation of the instructor's traditional role, we urge college instructors to reconsider Keller's Personalized System of Instruction as an effective format for today's chemistry student.

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