Integrating Concepts using Online Tutorials in a Freshman Chemistry Course

Weslene Tallmadge, Ph. D., Betty Jo Chitester, Ph. D., Gannon University

Authors' Contact Information

Weslene Tallmadge, Ph. D., Associate Professor and Chair
Betty Jo Chitester, Ph. D., Assistant Professor
Department of Chemistry, Gannon University, Erie, PA 16541;
Tel: (814) 871-7446
Email: tallmadge@gannon.edu & chitester@gannon.edu

Abstract:

Several years ago the traditional two semester chemistry sequence taken by freshman nursing students was replaced by a one semester Physiological Chemistry course at our university. This one semester course focuses on biochemistry content, requiring that students have already mastered important, introductory concepts, such as bonding, in their high school course. Variation in academic backgrounds left many students struggling to integrate the new course work with their weak, foundation knowledge. To reduce student frustration and increase student learning, online tutorials were introduced into the course to broadly cover the background topics, enhancing the course content. Students could work collaboratively or individually on the tutorials. The online tutorials were scheduled in a sequence that allowed for integration of the reviewed concepts into higher-level course work. Faculty noticed an improvement in the ease at which students integrated the concepts from the tutorials into learning new concepts in chemical systems. To further examine the effectiveness of the tutorials, both a pre-test and a post-test were administered to the students. In addition, students were surveyed regarding the perceived effectiveness of the online tutorials to review background material.

Key Words:

first-year undergraduate; chemistry; non-major courses; tutorials; course progression; online tutorials.

Introduction

All commonly accepted learning theories recognize that students learn by organizing and connecting new material to their previous knowledge (Ausubel, et al. 1978; Gagne, 1985). Ausubel's famous statement, "The most important single factor influencing learning is what the learner already knows," emphasizes the relevance of previously gained knowledge (Ausubel, et al. 1978). Teachers can certainly facilitate student learning by associating new concepts to those previously mastered. Of course, prerequisites are followed for college level courses to ensure that all students have

acquired the foundational concepts necessary for success in upper level coursework. Ideally, at the college level instructors communicate about coursework at various levels. However, freshmen level courses that rely on specific content mastered in high school courses can result in frustrating problems for both students and faculty. This is particularly a problem with content intensive course work in such fields as chemistry. Assuming that first year college students have the skills needed to identify learning objectives and review those in which they are weak may not be appropriate. Variation in student background may lead to teachers spending a significant amount of class resources reviewing prerequisite course work. Such is the case for a one-semester chemistry course at our university for which the prerequisite is one high school level chemistry course. Variation in high school chemistry course work resulted in significant time in class attempting to teach foundational principles rather than addressing current coursework. Some students were well prepared to advance their knowledge, while others were not. The following discussion illustrates an action plan that we employed to address these difficulties.

Background

For many years, chemistry faculty members have been charged with the goal of educating students majoring in the health professions regarding General, Organic and Biological Chemistry. A majority of students in these chemistry courses at our university are in the nursing major. For many years, educators have struggled with questions such as, “which fundamentals of chemistry need to be included in these courses to enhance the students’ ability to study in-depth topics in the health field;” and “what minimal background in organic chemistry is needed to understand topics in biochemistry.” Reports issued by the “Committee on Chemical Education for the Health Professions” have helped to clarify by issuing proposed syllabi for both one-semester and two-semester chemistry courses for health professions (Treblow et al., 1984; Daly and Sarquis, 1987). A questionnaire sent to teaching faculty of the allied health professions clearly indicated a desire for more biochemistry instruction for the students (Dever, 1991). In addition, a national survey was completed to clarify the chemistry topics considered to be important to nursing faculty at BSN departments for their students to explore (Walhout and Heinschel, 1992). Since then, innovative approaches have occasionally surfaced to focus student learning on appropriate content in the short time period allotted to the chemistry curriculum for students majoring in the health professions (Dunstan et al., 1997; Frost et al., 2006).

Prior to the year 2000, our department offered a traditional two-semester course sequence, Chemistry of Life I and II, which fulfilled the chemistry requirement of freshmen for the nursing major. This sequence of courses covered general chemical principles during the first semester followed by organic and biological chemistry the second semester. The principles covered in the biological chemistry portion are those of greatest interest to those in the nursing program. As is the case with many nursing programs across the nation, program changes within the curriculum necessitated replacing the two semester chemistry sequence with a one semester course focused on organic and biological chemistry.

As the program requirement went from a two semester sequence to a one semester course, students were required to have a background in general, chemical principles from high school. Acceptance into the university's nursing program requires one high school chemistry course to cover general chemical principles. The new one semester course, Physiological Chemistry, was taken by first-semester freshmen beginning in the fall of 2000, and was focused on organic and biological chemistry and was built upon the general principles.

Of course, nontraditional students were clearly at a disadvantage in Physiological Chemistry, since many years may have passed since their high school experience; however, many traditional students were not well-prepared either. Variation in academic backgrounds left many students struggling to integrate the new course work with their weak foundation knowledge of general chemical principles. While teaching the new course, Physiological Chemistry, it was apparent to the instructors that many students were lacking fundamental knowledge of general principles. Some students had poor preparation in high school; while some students did not know how to review material that they had covered in their sophomore or junior year of high school. The faculty noted that most freshmen are not able to organize the information to review principles that they may be lacking. As a result, the faculty members who were teaching the new one semester Physiological Chemistry course were not able to cover the pertinent biochemistry adequately because they found it necessary to cover the general principles during class time. In addition, students were not able to integrate general chemical principles with the organic and biological chemistry content of the course adequately.

To reduce student frustration and increase student learning, online tutorials were introduced into the course to cover the general principles, enhancing the course content. Tutorials, rather than class time, were used to address the prerequisite knowledge. This approach was chosen to minimize the in-class time and instructor load required to review prerequisite material.

General Principles and On-line Tutorials

First, the faculty members teaching Physiological Chemistry identified six general topics that the majority of students struggled to integrate into the organic / biochemistry course. The selection of these topics was based on both past teaching experience of the faculty and knowledge of the topics covered in a typical general principles text. Both instructors had extensive teaching experience with the course and used this experience to identify topics that many students needed help reviewing. The topics included atomic structure, chemical bonding, intermolecular forces, acids and bases, oxidation and reduction, and solutions. Measurable objectives were assigned to each of these topics. These topics were important to integrate into new material in a sequential order throughout the semester. For instance, tutorial four covered fundamentals of acids and bases. The learning objectives of this tutorial were to identify acids and bases, to identify conjugate acid base pairs, to write products of acid base reactions, and to relate concentration of hydronium ions to the pH scale.

Tutorials were presented in PowerPoint® or PowerPoint with Producer® format and made available to the students on-line through a course management program. The

PowerPoint with Producer® format was used to provide voice synchronization with the visual slides. Each tutorial reviewed a general principle topic and concluded with an assignment. Students could work at their own pace on the tutorials although each had a specific due date. The due date for each was chosen carefully such that the students would be finished with a tutorial before it was necessary to integrate that knowledge into new material in the classroom. Students could work individually or collaboratively on the tutorial, but each student was required to turn in his/her own assignment. Students received the graded tutorial back prior to the reviewed objectives being integrated into the new course material. Grading the tutorials did increase the assessment load for the faculty, although assignments were intended to be short and concise. Another option would be multiple choice questions that could be graded on-line immediately within the course management system.

The online tutorials were scheduled in a sequence that allowed for integration of the reviewed concepts into new, organic or biochemical, course work. For instance, prior to learning about organic acids and amino acid structure, the first four tutorials were completed. Particularly important to ensuring that students had learned the correct fundamental principles were objectives from tutorial three (intermolecular forces) and four (acid base chemistry). After completing these tutorials, students could identify three major types of intermolecular forces among small molecules; identify acids; and identify acidic, basic and neutral conditions on the pH scale. Figure one illustrates the first of two questions from the assignment of the third tutorial. In this review, students were to identify three different intermolecular forces.

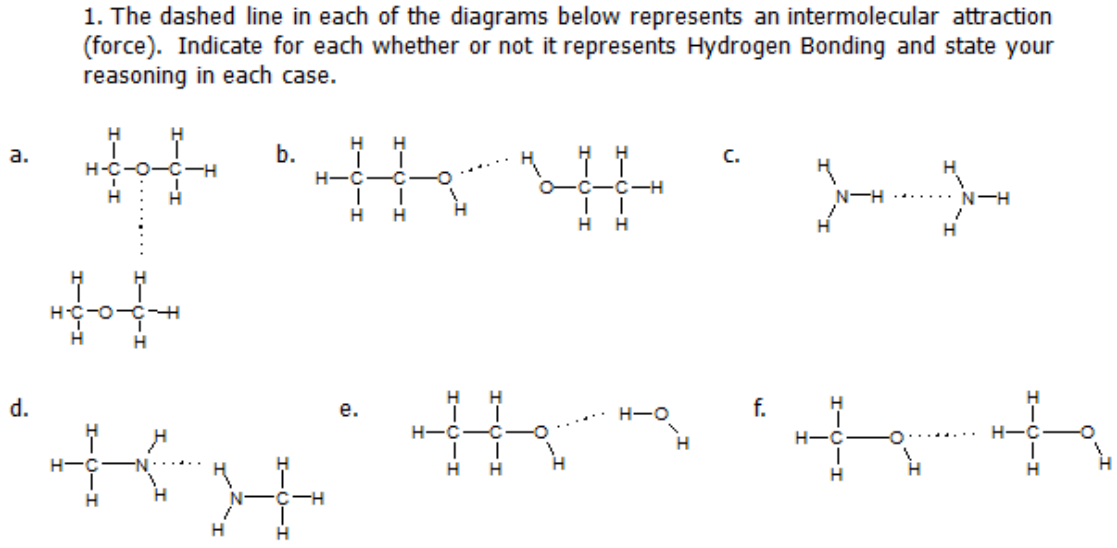

Figure 1. Tutorial Three Assignment

The fundamental principles reviewed in the third and fourth tutorial were used to teach students the course material; how pH level affects the molecular structure of an amino acid and then to predict the intermolecular forces of protein side chains.

Evaluation of On-line Tutorials

Both instructors noticed an improvement in the ease with which students integrated the foundation principles from the tutorials into learning new concepts. To examine the effectiveness of the tutorials, both a pre-test and a post-test were administered to the students. Near the end of the semester, students were surveyed regarding the perceived effectiveness of the online tutorials.

1. Within one week of the start of the semester, a pre-test was administered to the students. The pre-test examined some of the general principles assumed to be covered in a high school course. The test consisted of 30 multiple choice questions; five questions covered each of the six topics. Students took the test on-line at any time throughout the week but had to finish the test within 30 minutes once it was started. Re-taking the test was not permitted. Students were given 5 participation points, making the pre-test a low stakes event. Sixty two students took the test. The average score was 12 correct responses out of 30 questions (40%) with a range of 7 to 23. The median score was 13. The low number of correct responses indicated that students did need to review the prerequisite materials.
2. Six tutorials were made available to students on-line. Each tutorial was dedicated to one of the six target topics identified by the faculty, listed previously. Assignments attached to the tutorial were worth 5 points each. Ninety six per cent of the total assignments were completed and submitted by students. The average grade was 4.2 out of a possible 5.
3. Students were given a post-exam three weeks prior to the end of the semester; two weeks after completion of all tutorials. The exam assessed student understanding of the material presented in the tutorials. This exam was worth 60 points out of a total of 600 points for the course. Students were not made aware, but the post-test was the same as the pre-test. The test consisted of 30 multiple choice questions with 5 questions devoted to each of the 6 topics. Students took the post-test in class for monitoring purposes. The average score improved significantly as compared with the pre-test to 22 out of 30 (73%) with a range of 11 to 27 and a median of 22. The average score increased 33%, with a minimum increase of 13% and a maximum increase of 57%.

Table I. Pre and Post-Test Correct Responses

	Pre-Test	Post-Test
Average Number of Correct Responses	12	22
Median	13	22
Range	7 to 23	11 to 27

4. On-line surveys were administered to the students during the last week of classes. Students were not required to complete the online survey; however, 73% of the students did so. Of those who did, 58% said the tutorials provided them with a “good

review or learning experience," 50% responded that they had worked with another (or other) student(s) to complete the tutorials, 91% of those that had 'worked with others' said it was helpful for them to do so and 77% responded "yes" to "Would you recommend using the tutorials in future classes?"

Table II. Student Survey Responses

Did you work with other students on the tutorials?	50% yes
Was it helpful to work with others, if you did so?	91% yes
Would you recommend using the tutorials in future classes?	77% yes

Conclusion

Assuring that students successfully complete prerequisite courses is a basic step in course design followed in higher education. However, high school courses at different schools may not consistently teach students continuing to the college level what they need to know. Instructors teaching students at the freshmen level may struggle to determine reasonable expectations of previous learning for students with diverse backgrounds. Careful designing of tutorials for use outside of class may alleviate some of the stress of attempting to bridge this learning gap that some of the students may have. The use of online tutorial reviews of chemical principles has enhanced both the academic performance of our students and the quality of the course. Biological chemistry is important in the nursing program. Using online, self-paced tutorials assisted the students in compensating for insufficient background in chemical principles, allowing the class to progress faster into the biological chemistry. While other approaches may accomplish the same goal, this approach minimized the in-class time needed for review of background material and increased feedback to students.

Acknowledgments

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