5-Star Instructional Design: Evaluation of Web-Based Instruction in Medical Science

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Abstract

The purpose of this study was to evaluate Web-based instructional modules that simulated medical diagnosis. The modules were designed by a medical sciences professor for use by second-year medical students in his pathology course. Medical students were subsequently surveyed during their third-year clinical rotations when they were working in real settings. The survey instrument was based on the 5-star instructional model, most recently published as "first principles of instruction" (Merrill, 2002). We report the results of this survey from two cohorts of medical students. After statistical analysis and elimination of several less consis tent questions, our 5-star rating scale had an overall internal consistency reliability of 0.94. The medical sciences professor was not aware of Merrill's first principles when originally developing the Web-based modules. Third-year medical students surveyed in this study agreed that the modules incorporated first principles of instruction. Merrill postulates that instruction is most effective when it utilizes first principles.

Background of this Study

In September, 2001 a medical sciences professor approached this team of researchers with a request to assist in the evaluation of Web-based modules that he had designed and been using in his second-year pathology course. Although his class was small (n=25), the modules represented a large commitment in terms of time and effort. He was interested in 1) knowing if the modules were effective, and 2) having an evaluative tool designed for long-term use. The modules are publicly available at http://bl-msci-007c.ads.iu.edu/c602web/602/start.htm.

The modules have been in use for the past two years in his class. They were designed as supplements to create "real-life" situations for students where diagnostic skills could be practiced. As the modules unfolded, students were required to make decisions based on initial perceptions, questioning of patients, results of tests that could be administered, etc. After each module, students were required to take a quiz, the score of which counted toward their grade in the class.

The pathology course is part of a regional medical school program. Medical students enroll in their first two years at one of nine local campuses. The students whom we surveyed had used the online pathology modules during their second year at a regional campus, but were contacted during the third year after having completed two or three clinical rotations. Rotations occur at hospitals and other supervised clinical settings where students are required to make diagnostic decisions that affect the lives of real people.

As this team of researchers sought a tool with which to evaluate these modules, David Merrill's 5-Star Instructional Design Rating system was selected as a starting point. The 5-star rating scale is based on Merrill's (2002) first principles of instruction. The reader should note that the medical professor who designed the Web-based pathology modules was unaware of Merrill's work at the time. The professor was interested in evaluating the effectiveness of his modules. Since he had not collected pre- and posttest achievement data at the time the medical students used the pathology modules, it was not possible to get direct measures of instructional effectiveness. However, if medical students were to rate the modules with an adapted version of Merrill's 5-star rating scale, then this would be a post-hoc indicator of their effectiveness.

Literature Review

The Web-based instructional pathology modules evaluated in this study present three areas of interest to researchers: 1) techniques for developing medical student skills; 2) the use of problem-based learning to improve medical school preparation; and 3) methods of evaluating real world problem-based learning as to whether it effectively prepares students for patient interaction. Much of the literature regarding medical school education focuses on the development of clinical and patient-centered skills (Haidet, Dains, Paterniti, Chang, Tseng & Rogers 2001). For example, Peterson, Holbrook, Hales, Smith and Staker (1992) considered history taking, the patient examination and laboratory results as the cornerstone of most diagnoses. To better illustrate the importance of this point Hasnain, Bordage, Connel & Sinacore (2001) stated, "The great majority of medical diagnoses, up to 90% in the case of chest pain, for example, are made on the basis of the history alone. Although this is well established, the history-taking behaviors of medical students and residents have received little attention as a measure of diagnostic

reasoning." (p. S14) Peterson et al. (1992) concluded that expert doctors emphasize history but medical students cling to diagnostic tests. As they gain more experience, the students show an improved use of history and improvement of patient interviewing skills. In addition, the test results and a physical exam provide support for decisions made based on history. In fact Peterson et al. reported it was difficult to evaluate these three tools individually because they were each so vital to a reliable diagnosis in practice. Medical programs have been using a variety of methods to teach a level of proficiency in these three critical skill areas. Some studies have investigated the use of mentoring relationships (Chou, 2001), while others have engaged students in simulations (Sakowski, Rich & Turner, 2001; Zvara, Olympio & MacGregor, 2001). These studies all stressed early acquisition of the techniques to build clinical skills.

The use of problem-based learning (PBL) is well documented in the research literature. While there are multiple characterizations of the term 'problem-based learning,' for the purposes of this paper we accept the definition put forth by Albanese and Mitchell (1993), where PBL is defined as "an instructional method characterized by the use of patient problems as a context for students to learn problem-solving skills and acquire knowledge about the basic and clinical sciences." (p. 55) What distinguishes problem-based learning is the presentation of a problem before students have learned basic diagnostic concepts. In addition, most problems do not provide students with all of the information necessary to solve them. They need to seek resources and additional information as they move toward a solution. Furthermore, problems that are presented to students should be compelling and interactive. Faculty instructors' responsibilities are to support student solutions, not provide answers or direction (Albanese & Mitchell, 1993).

Going beyond the PBL literature, Merrill (2002) has identified four additional phases -- derived from extant instructional theories -- that are necessary for instruction to be most effective. Together, he refers to these five as "first principles of instruction." Learning is promoted when:

1. Learners are engaged in solving real-world problems.
2. Existing knowledge is activated as a foundation for new knowledge.
3. New knowledge is demonstrated to the learner.
4. New knowledge is applied by the learner.
5. New knowledge is integrated in the learner's world. (Merrill, 2002, pp. 44-45)

Methodology

In designing the assessment tool, we took each of the five principles and brainstormed a series of ten or more questions for each principle. Questions were tested for wording and understanding with current medical school students and many were either discarded or reworded. The list of questions for each principle included negatively worded queries as well as positive ones. The list was narrowed to a final, comprehensive list of 31 questions, which were then randomly ordered in the assessment. In addition, several introductory questions were placed at the front of the assessment as a means of collecting demographic data and open-ended questions were added at the end to give participants a venue for explaining or expounding upon answers.

Two cohorts of students were surveyed in the fall of 2001 and 2002. Each group of students had completed at least two clinical rotations; however, many of the students in the 2001group had completed three at the time of responding to the survey. The survey was administered by means of an online survey and testing tool used by the institution. This tool was selected because students had already taken several tests and surveys with the tool and were familiar with it; it allowed for remote access from their diverse clinical assignments; and it protected the students' anonymity while preventing multiple submissions by the same individual. The professor who developed the modules contacted the participants by e-mail. They were given a link to the modules and information regarding the length of time they would be available.

Results

Eleven students responded to the survey in each cohort, for a total $n = 22$. The results fromboth years were pooled into one set of responses. The medical professor who designed the modules was asked if the second group of students would have experienced different modules than the first, and he assured the team that only minor changes had occurred over the two years. The larger n would allow for a more effective evaluation of the reliability of the questions.

The reliabilities of the survey scales were examined by first looking at each group of questions according to Merrill's five principles and analyzing them using Cronbach's alpha coefficient for internal consistency. After

running the test on all of the questions in each category, we looked to see if the scale for each of the five principles could be improved by removing items that were less consistent with the scale. Consequently, the pool of questions was reduced from 31 to 22. Confirmatory factor analysis of the scales was not possible due to the relatively small sample size. The resulting scales and questions are listed in Table 1.

Table 1. 5-Star Scales for Evaluating the Pathology Modules and their Reliabilities

Instructional Principle	*Scale Items*	*Number of Reliable Questions*	*Alpha Value*
Problem	-The online pathology modules were presented in the context of real world problems. *The medical problems posed in the online pathology modules were unrealistic. - The online pathology modules utilized very practical medical situations. - I have encountered medical situations in my clinical rotations that were similar to case(s) presented in the online pathology modules. * I have not had ANY cases that resemble the examples in the online pathology modules.	5	.84
Activation	*When I began each module, I was overwhelmed by all the new information, and didn't know how to begin. *The online pathology modules had little relevance to what I really need to know to become a doctor	2	.67
Demonstration	-The online pathology modules showed examples of what was to be learned rather than merely give information to me. * The online pathology modules were no different than reading the book. -The graphic images and video clips in the online pathology modules made the procedures and techniques clear to me. - I found the graphic images and video clips in the online pathology modules helpful. -There were sufficient examples of normal and abnormal conditions to make appropriate diagnoses.	5	.73
Application	-Through the online pathology modules, I had an opportunity to practice and apply the knowledge and skills I had just learned. -The manner in which information was presented in the online pathology modules helped to clarify misunderstandings or misconceptions that I had. -The online pathology modules provided me with an opportunity to practice diagnostic decisions in a "safe" environment. -By completing successive pathology modules throughout the course, I gained a sense of my intellectual development. -The step-by-step design of the online pathology	5	.77

	modules allowed me to apply what I had been learning in class.		
Integration	-The online pathology modules provide techniques that encouraged me to integrate the new knowledge or skill into my medical school experiences. -The pathology course provided me with opportunities to demonstrate what I learned on the online pathology modules. - Concepts that I learned in one online pathology module could be used to help me . *The information I gained from the online pathology modules was not useful to me after completing the pathology course. - I have used concepts that I learned through the online pathology modules in diagnosing patients.	6	.83
Combined First Principles		22	.94

*Response values for items with negative wording were reversed for analysis.

Reliabilities varied for each of the five categories. The lowest reliability of alpha = 0.67 was associated with the 'Activation' scale, after removing all but two questions. The highest reliability was observed for the 'Problem' scale with alpha = 0.84. When examining all 22 remaining questions, we found that the scale as a whole had an alpha value of 0.94, a high level of reliability. Since the reliability value is higher when looking at the scales combined than any of the individual scales, this may indicate that the five-star criteria have greater reliability when applied together rather than separately. Four of the scales had reliability above 0.7, which according to Nunnaly (1978) is an acceptable level for Cronbach's alpha.

In addition, we looked at subject's average ratings for each of the five principles. The mean average scale value for each principle was approximately 2.0. The scale used on the survey ranged from 1 = strongly agree, 2 = agree, 3 = neither agree nor disagree, 4 = disagree, to 5 = strongly disagree. Scoring of negatively worded questions was reversed before analysis. The overall mean rating of 1.86, based on the scales created using all five first principles of instruction, indicated that students agreed that the online pathology modules were effective forms of instruction. Activation showed the greatest discrepancy with responses ranging from 'strongly agree' to 'strongly disagree.'

Table 2. Descriptive Statistics for each Scale

First Principle	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Problem	1.00	2.60	1.80	.41
Activation	1.00	4.50	2.02	.73
Demonstration	1.00	2.40	1.65	.42
Application	1.00	2.60	1.97	.38
Integration	1.00	2.60	1.92	.43
Combined First Principles	1.10	2.46	1.86	.37

Overall we felt that the 5-star criteria did indeed provide an excellent framework from which to develop scales to assess these online pathology modules. The students responded positively to the questions. Information collected from the open-ended questions provides some insights as to what aspects and modules respondents found most useful in their current situation. Of the responses received, CBC review was mentioned the most often with five responses. Other modules that were mentioned specifically were: myocardial infarction, diabetes, blood pathology, cardiac pathology, gallstones, lung cancer, woman with morning stiffness, chest pain, dyspepsia, vaginal bleeding,

abdominal pain, hematology, leukemia and alcoholism. Clearly, for some reasons, these stood out in the minds of the respondents, many of them listing more than one module.

Summary and Conclusions

The first goal of this study was to evaluate the relevance of the information presented in the pathology modules to students enrolled in their third-year clinical rotations. As can be seen in student responses to the problem-oriented criteria for the first principle, the pathology modules seem to have been effective towards this goal. For example, to the question, "I have encountered medical situations in my clinical rotations that were similar to case(s) presented in the online pathology modules", 20 out of 22 respondents stated they agreed or strongly agreed with this statement. Responses to such questions support the usefulness of the information presented to students during the clinical rotations and encourage the collection of longitudinal data. A stronger argument can be made using the average rating according to all five criteria combined. The average rating of 1.86 indicates that the respondents agreed that the modules helped them generate ideas and apply diagnostic concepts to real world situations, and actively practice skills that they would later use in clinical experiences.

Responses for improving the modules were diverse, but there were two suggestions that were repeated by multiple respondents. These included having the modules be more interactive with more multimedia, and making them more difficult. Students also commented on choices that were presented in the module. For example, some of the choices were mentioned as being clearly wrong (i.e. letting a patient go home when they were clearly not well). There was some interest expressed in having more choices as well as more difficult choices. Additionally, a student suggested that the pathology modules should incorporate topics from other classes. This suggestion, if valid, may point to one reason why activation scored lower than the other four principles. Incorporating material from other classes would increase the amount of activation of prior knowledge required of students for each case. In upgrading and maintaining the modules, this should be taken into consideration.

This study could prove to be a valuable place to launch new studies. First, results could be compared with other data sources such as class rankings and the USMLE (US Medical License Examination) results for validity studies. Secondly, these modules are beginning to be used at other institutions. Comparisons of student responses across different contexts would be valuable to show the effectiveness of the modules removed from the class setting in which they were originally used. Finally, additional support for depth of the evaluation could be established by pairing this tool with practical measures of clinical skills such as supervisor evaluations of clinical students.

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