TOWARDS A MODEL FOR EVALUATING STDUENT LEARNING VIA E-ASSESSEMENT

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ABSTRACT

The need for practical tools to assess student learning at the course level is becoming a more pressing goal for all academic institutions. This situation arises because learning assessment tools which monitor both student performance and conceptual change events that lead to improved learning ultimately provide the basis for the subsequent assessments of programs and institutions. In addition to having validity, reliability, transparency, and fairness, a viable and efficient e-assessment tool at the course level possesses the following critical characteristics - 1) the ability to be integrated effectively within the existing course structure, 2) the ability to generate quantitative, measurable results, and 3) the ability to provide timely feedback. This paper proposes a model for assessing student learning at the course level which utilizes, in part, online assessment methods (e-assessments) to achieve these characteristics. More specifically, the model provides a description of how assessment may be embedded into an existing course and illustrates the utilization of online pre/post-tests and knowledge surveys as a source of assessment data. The subsequent data analysis, based in part upon Bloom's revised taxonomy, demonstrates how the results are used to determine the level of learning achieved. The paper concludes with a proposal for future work wherein the model is tested to determine its ability to detect changes in student learning originating from the implementation of a pedagogical strategy such as online tutoring.

KEYWORDS

Teaching and learning in science, e-assessment,

INTRODUCTION

The purpose of assessment is to “engage a campus community collectively in a systematic and continuing process to create shared learning goals and to enhance learning” (Student Learning, 2007). In an era when increased public support for education being subjective to increased student outcomes, the need to define and measure learning has increased as well. In particular, the United States government mandated-program “No Child Left Behind” (No child, 2001) serves as an excellent example of this trend. The use of technology to deliver and analyze assessments in an effective and efficient manner has been the focus of current research (Whitelock, 2007). Furthermore, the Joint Information Systems Committee (e-Assessment Introduction, 2008) in the United Kingdom has supported the innovative use of e-assessment defined as “the end-to-end electronic assessment processes where ICT is used for the presentation of assessment and the recording of responses”. Regardless of the way in which the assessment is performed, any e-assessment tool must possess the following characteristics (Perrie, 2003) -

- The assessment provides a valid and accurate measure of what is being assessing.
- The assessment clearly measures the intended learning objectives.
- The assessment is reliable and provides consistent results when employed by other assessors.
- The assessment provides an equal opportunity for success for all students.
- The assessment is effectively and efficiently integrated within the existing course structure.
- The assessment provides the timely feedback.

Of importance to this paper and the model proposed here is the inclusion of an additional characteristic -

- The assessment generates quantitative and measurable results.

In view of both the need for and content of assessment tools, a model for evaluating student learning through e-assessments emerges which follows five steps of development –

- Defining learning
- Quantifying learning
- Collecting data
- Measuring learning
- Identifying activities to improve learning

DEFINING LEARNING

Bloom's revised taxonomy, illustrated graphically in Figure 1, provides for the development of a valid and quantitative assessment tool. In this new view, the relationships among cognitive processes (remembering, understanding, applying, analyzing, evaluating, and creating) and knowledge outcomes (factual, conceptual, procedural, and metacognitive knowledge) are set forth as described in Table 1 (Pickard, 2007). In particular, the acquisition of higher levels of knowledge results as students master each successive lower level cognitive process. Pervading this learning sequence is the awareness of students of the cognitive processes they possess – their metacognitive knowledge.

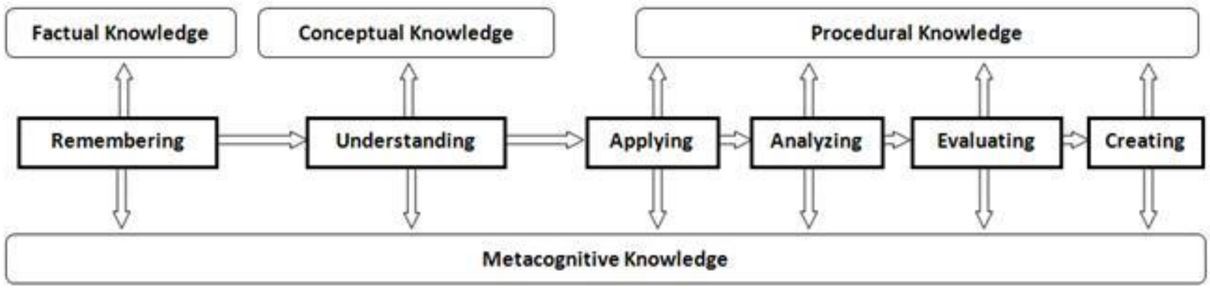

Figure 1. Bloom's Revised Taxonomy

Table 1. Knowledge outcomes

Factual Knowledge	The basic elements students must know to be acquainted with a discipline or solve problems in it
Conceptual Knowledge	The interrelationships among basic elements within a larger structure that enable them to function together
Procedural Knowledge	How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods
Metacognitive Knowledge	Awareness of cognition in general as well as awareness of one's own cognition

From this taxonomy the following definitions of knowledge, knowledge level, and learning emerge.

- Knowledge is the acquisition, comprehension, or manipulation of information and the awareness of the cognitive processes used and
- Knowledge level is the measure of the degree to which knowledge has been achieved,
- Learning represents a change in knowledge level toward higher order skills.

QUANTIFYING LEARNING

With learning thus defined, the model now addresses the quantification of learning. As previously described, the knowledge level comprises either factual, conceptual, or procedural knowledge as well as metacognitive knowledge.

Firstly, the determination of the performance level (PL) occurs which measures the level of either factual, conceptual, or procedural knowledge possessed by students. For example, assessment of the factual level of knowledge requires questions testing the recall of such items as units or equations. At the conceptual level, questions aim at assessing how well information such as concepts or laws is understood or comprehended. In this instance, students must describe or explain qualitatively how a given concept works or what a law predicts. Assessment of performance at the procedural knowledge level (problem solving) results from questions requiring the application, analysis, and evaluation of information to solve problems. In short, students answer questions use the information to solve problems and draw conclusions. In each case mentioned above, the selected questions clearly reflect the desired learning outcomes.

Secondly, the assessment of students' awareness of their metacognitive knowledge take place. Research indicates a significant positive correlation between levels of confidence and the use of effective learning strategies and self-regulated learning skills such as monitoring problem learning strategies (Okamoto, Leighton, and Cor, 2008). In view of this research, the confidence level students possess is thus employed in the model as a measure of their metacognitive abilities. To assess the confidence level, students rate the confidence (low, medium, or high) in their ability to carry out the cognitive processes previously assessed. For example, students rate their ability to recall units and equations, to explain how a concept works or what a law predicts, or to solve problems and interpret the results.

Figure 2 illustrates an example of the quantitative assessment of performance levels and confidence levels associated with a typical physics course. As shown in the figure, questions 1 and 4 reflect the metacognitive level for the stated outcome. These questions are then followed by a series of questions used to evaluate the current knowledge level associated with that outcome. (In the interest of space, only a partial number of knowledge level questions are shown.)

1. State the quantities, dimensions, and equations used to express Coulomb's Law and the electric field.

	low	medium	high
Confidence level	○	○	○

2. Which one of the following represents the standard unit of charge?

   ○ ampere

   ○ coulomb

   ○ joule

3. Which one of the following represents the relationship between the electric force experienced by two charges and the distance between the charges?

   ○ The force is directly proportional to the distance

   ○ The force is directly proportional to the square of the distance

   ○ The force is inversely proportional to the square of the distance

4. Use Coulomb's Law or the electric field equation to predict what happens when a specific quantity or quantities change?

	low	medium	high
Confidence level	○	○	○

5. Two charges, q_1 and q_2, are separated by a distance r, with the result that each charge feels a force F. The charge on q_1 is now increased by a factor of 3 and the charge on q_2 is increased by a factor of 2 and the distance between the charges is now cut in half. Which one of the following describes the electrical force felt by each charge?

   ○ 3 F

   ○ 12 F

   ○ 24 F

6. Three identical charges (same sign and magnitude) are aligned at equal spacing along x-axis. The magnitude of the force felt by the charge in the middle and the charge to its left is F, and the magnitude of the force felt by the middle charge and the charge to its right is again given by F. Which one of the following describes the net electrical force felt by the middle charge?

   ○ 0 F

   ○ 2 F

   ○ 4 F

Figure 2. Illustration of the evaluation of confidence and performance levels

COLLECTING DATA

At the core of the model is the collection and analysis of data pertaining to the performance and confidence levels as shown in Figure 2. The need for a means of administering the assessment tool that results in the least amount of negative impact to the instructors teaching and the students learning is vital. The accomplishment of this goal requires the use of online surveys. The capability of these websites to design surveys and collect and analyze the resulting data allows for assessment questions to be readily integrated into e-mails, webpages, and PowerPoint presentations. In addition, surveys are available to be completed either in or away from the classroom. Although security remains a concern for any such online assessment, research as indicated methods to minimize occurrence of cheating (Hench, 2010). Furthermore, the instructor can greatly shorten the turn-a-round time for the acquisition of feedback. A link to the complete e-assessment survey shown in Figure 2 is available at the end of this paper.

Learning, as previously defined, represents a change in knowledge levels. Thus, the use of pre- and post-assessments allows for the collection of data used to identify any shifts in knowledge levels. As was the case for the creation, integration, and analysis of online surveys, the online surveys provide a means to administer an assessment on multiple occasions and at different locations. Hence, the use of online surveys provides an effective and efficient means to collect and analyze the data necessary to assess learning.

MEASURING LEARNING

The analysis of data acquired via e-assessments as described in the previous section then allows for the measurement of any occurrence of learning. In the case described here, the data represents the average knowledge and confidence levels of the entire class. However, individual results are analyzable in the same manner. The analysis of the data produced from the surveys begins by locating each set of performance and confidence level data diagram. This diagram, referred to as a PCL diagram, is presented in Figure 3 for data acquired using the complete set of assessment questions shown in part in Figure 2.

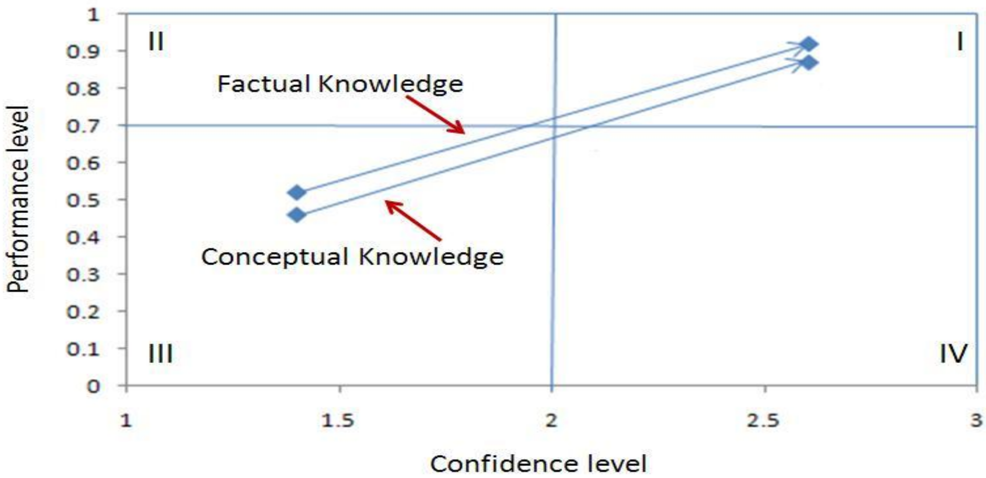

Figure 3. Performance/ Confidence Level diagram

In the PCL diagram, the horizontal axis represents the confidence level and the vertical axis the performance level. For the case shown here, the minimum acceptable performance level and confidence level correspond to 0.70 and 2.0, respectively. These minimum acceptable levels form the boundaries used to divide the diagram into four quadrants. Table 2 shows the general characteristics of the students whose knowledge and confidence levels correspond to each quadrant.

Table 2. Knowledge level quadrants of PCL diagram

Quadrant I	The student demonstrates an acceptable level of achievement for the knowledge outcome assessed and possesses the associated metacognitive knowledge skills.
Quadrant II	The student demonstrates an acceptable level of achievement for the knowledge outcome assessed, possesses acceptable strategic or conditional knowledge skills, but lacks confidence in those skills.
Quadrant III	The student demonstrates an unacceptable level of achievement for the knowledge outcome assessed and while indicating confidence in the metacognitive knowledge skills possesses unacceptable strategic and/or conditional knowledge.
Quadrant IV	The student demonstrates an unacceptable level of achievement for the knowledge outcome assessed and possesses unacceptable strategic and conditional knowledge skills.

For the situation illustrated in Figure 3, online pre-tests of performance and confidence levels placed the students' knowledge levels for factual and conceptual knowledge in Quadrant III. After receiving instruction, students' post-test results showed knowledge levels in Quadrant I. Inasmuch as learning is defined as a change in knowledge levels toward higher order skills, the results displayed on the PCL diagram indicate that learning has occurred on the factual and conceptual levels for the stated learning outcome. It is important to note that the progress of individual students or all students' knowledge level toward higher levels and higher order skills is traceable through additional intermediate assessments of performance and confidence. Thus, by careful selection of the question content, the instructor construct an assessment model to reflect a clear measure of whether or not learning objectives have been achieved. In addition, the quantifiable nature of the model allows for the reliable comparison and consistency of results when employed by other assessors, thereby providing an equal opportunity for success at learning for all students.

IDENTIFYING ACTIVITIES TO IMPROVE LEARNING

As indicated in Figure 3, the overall factual and conceptual knowledge level of students increased, moving from quadrant III to quadrant I. Such change results from the use of, feedback supplied by the online assessment. Table 2 provides possible activities for the improvement of the knowledge level within each quadrant.

Table 3. Improvement Activities for quadrants of CL/PL diagram

Quadrant	Improvement Activities
I	Further refinement of existing skills
II	Peer tutoring of other students to increase confidence and improve other skills
III	Refocus on factual, conceptual, or procedural knowledge skills
IV	Re-evaluation of entry level skills, strengthen pre-requisites

DISCUSSION AND CONCLUSIONS

As developed and implemented here, the model for assessing student learning via e-assessment possesses the previously stated characteristics of an effective assessment tool. In particular, the model demonstrates the use of Bloom's revised taxonomy to provide a valid measure of intended learning objectives by defining learning in terms of knowledge levels. Specifically, the measurement of both performance and metacognitive levels allows for a deeper measure of learning to be assessed. These clearly defined levels, in turn, illustrate the capability of the model to provide reliable and consistent results while maintaining an equal opportunity for success for all students. As an example, the integration of the model into a physics course via the use of online surveys showed how such an e-assessment tool efficiently fits into an existing course structure to provide timely feedback and data analysis. Of particular importance, the model generated quantitative and measurable results which permit the tracking of learning resulting from pedagogical interventions. Thus, the model presented here provides both the theoretical and practical means for measuring learning via e-assessments.

FUTURE WORK

A further test of the model as described here is planned by the authors wherein the effect of online peer tutoring is investigated as a pedagogical strategy to raise student knowledge levels. As part of this research, the scope of the model will be extended into developing and measuring the higher order thinking skills required for the acquisition of conceptual and procedural knowledge.

Internet link to the online assessment survey referenced in this paper –
http://www.surveymonkey.com/s/CBLIS

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