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Integrated Formative Assessment as a Vehicle toward Meaningful Learning in the Systems Analysis and Design Workshop

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ABSTRACT

This research was performed within the systems analysis and design workshop. In addition to standard technical issues, this workshop consisted of a variety of tasks that were designed to enhance students' capabilities related to non-technical knowledge areas such as critical thinking, interpersonal and team skills, and business understanding. Each task was reviewed and assessed by both the students and the instructor. The main research study objective was to examine the effect of employing team-based peer-review and formative assessment in an information systems workshop on the learning process of the students. Data referring to the grading process will be presented and analyzed as well as the students' reflections which demonstrate their perception of the workshop's constituents.

Keywords: formative assessment, the SOLO taxonomy, systems analysis and design workshop, peer review

I. INTRODUCTION

Information technology is a fundamental part of modern society. Software based systems manage and control many aspects of our daily activities. Management Information Systems (MIS) provide organizations not only with tools for better management, but have become business boosting infrastructures [Laudon and Laudom, 2005; Bocij et al., 2005]. The systems analysis and design workshop is an important component of the MIS curricula and its objectives are to provide students with additional non-technical knowledge areas such as critical thinking, inter-personal skills, team skills, and business understanding. The workshop is a good framework for students to demonstrate and augment their understanding of using technology to develop new organizational processes and for achieving organizational goals.

Cognizant of the students' difficulties regarding non-technical knowledge, the workshop structure employed heavy usage of team-based peer review formative assessments and team assignments. The workshop stages follow the SOLO (the Structure of the Observed Learning Outcomes) taxonomy [Biggs and Collis, 1982] and elevated students' overall understanding to a higher level of abstraction. This paper describes the workshop structure and the encouraging quantitative and qualitative results obtained.

II. CONTEXTUAL FRAMEWORK

Assessment plays a major role in higher education's overall quality of teaching and learning. A well-designed assessment sets clear expectations, establishes a reasonable workload, and provides opportunities for students to self-monitor, rehearse, practice and receive feedback. For MIS graduates who have to demonstrate their proficiency in "technology enabled business development" [Gorgone et al., 2002], assessments and peer reviews are even mandatory.

Students working toward their B.A. degrees are required to participate in certain courses that are not traditional lecture-based classes. In these

courses the students have to cope with learning a certain topic and then teaching it to the rest of the class. They must take full responsibility for both their own learning processes and for teaching the material to their classmates. Many researchers recognize the benefits and the importance of using Formative Assessment (FA) during the learning process [Wiggins and McTighe, 2000; William and Thompson, 2007; Saphier, 2005]. Aware of these advantages, we asked students to take an active part in the assessment process. At this stage of their studies, the students were already familiar with the technical aspects (Unified Modeling Language (UML) notation) of information systems engineering. The main objectives of the workshop were to provide knowledge, tools and expertise in the various components of systems development. In addition to understanding systems life-cycle, methods and models, the workshop strengthens the systems analyst non-technical qualifications. The workshop structure was based on incremental assignments that follow the software development life-cycle. Each assignment was reviewed and assessed by both the students and the instructor. The assessment and grading templates were provided for the students and were discussed in class. It should be stressed that the students were graded not only for their assignments, but also for their assessments, since the main research study objective was to examine the effect of employing peer-review and formative assessments in a computer science and information systems workshop on the learning process of the students.

III.THEORETICAL BACKGROUND

In what follows we present a brief theoretical background of assessment methods in higher education, specifically in regards to formative assessment and the advantages of peer review, and briefly present the SOLO (the Structure of the Observed Learning Outcomes) taxonomy which relates to the various stages of higher-order learning.

THE ROLES OF ASSESSMENT IN HIGHER EDUCATION

According to James, McInnis & Devlin (2002), the examination of student learning supports three objectives for quality in student assessment in

higher education: (1) assessment that guides and supports effective approaches to learning; (2) assessment that validly and reliably measures expected learning outcomes, in particular the higher-order learning that characterizes higher education, and (3) assessment and grading that defines and protects academic standards.

The relationship between assessment practices and the overall quality of teaching and learning is often underestimated, yet assessment requirements and the clarity of assessment criteria and standards, significantly influence the effectiveness of student learning [Gulknecht-Gmeiner, 2005]. Carefully designed assessment contributes directly to the way students approach their studies and therefore contributes indirectly, but effectively, to the quality of their learning. For most students, assessment requirements literally reflect the curriculum. Assessment is therefore a powerful strategic tool for educators to clarify which kinds of learning will be rewarded and to guide students into effective approaches to study.

Assessment is treated by educators and students as an integral and important component of the teaching and learning process rather than a final add-on to it. The powerful motivating effect of assessment requirements on students is understood and assessment tasks are designed to encourage valued study habits. There is a clear connection between expected learning outcomes, what is taught and learned, and the knowledge and skills assessed. Assessment tasks evaluate a student's ability to analyze and synthesis new information and concepts rather than simply remember information previously presented. A variety of assessment methods is employed so that the limitations of particular methods are minimized. Assessment tasks are designed to appraise relevant generic skills as well as subject-specific knowledge and skills. There is a steady development in the complexity and demands of assessment requirements in more advanced courses. Assessment tasks are weighted to balance the developmental (‘formative’) and judgmental (‘summative’) roles of assessment. Grades are calculated and reported on the basis of clearly articulated learning outcomes and criteria for levels of

achievement. Students receive descriptive and diagnostic feedback as well as numerical grades.

Students study more effectively when they know what is expected of them. Students appreciate and expect transparency in the way their knowledge acquisition will be assessed. They wish to see a clear relationship between lectures, tutorials, practical classes, and subject resources, and the knowledge they are expected to demonstrate. They also wish to understand how grades are determined and expect feedback that not only explains the grade received, but that rewards achievement appropriately. In addition they look for suggestions that enable them to improve themselves as learners.

Capturing the full educational benefits of a well-designed assessment requires that many of the conventional assumptions about assessment in higher education be reconsidered. For the academic staff, assessment is often a final consideration in the planning of their curricula. This is not to imply that staff underestimates or undervalues the role or importance of assessment, but assessment is often considered only after other curricular decisions have been made. The primary concerns of academic staff are often with designing learning outcomes and planning teaching and learning activities that will produce these outcomes. In contrast, students often work 'backwards' through the curriculum, focusing first and foremost on how they will be assessed and what they will be required to demonstrate they have learned.

As was previously mentioned, assessment tasks are weighted to balance the developmental ('formative') and judgmental ('summative') roles of assessment. An elaboration on formative assessment, an assessment method which we employed in the present study follows.

FORMATIVE ASSESSMENT

Formative assessment (FA) is any assessing assignment aimed at enhancing student learning. These assignments provide both teachers and students with feedback which might prompt revisions in the way teachers teach and students learn. FA necessitates constant follow-up

and as a result the teacher is regularly informed regarding the students' progress or difficulties and can adjust his/her teaching accordingly. Through FA the teacher can know whether what has been taught has been learned. It allows teachers to reflect on their practice and to make incremental changes that improve that practice in powerful ways. William and Thompson (2007) suggest five strategies for establishing effective FA: (1) understanding, cooperation, and perception of the learning aims and setting criteria for success with students. Wiggins and McTighe (2000) support a two-step process in which the learning aims are clarified and then clear criteria for success are set (considered 'understanding'); (2) using effective class discussions, tasks, and activities which reflect the course of reaching the learning aims; (3) providing the students with feedback which can promote the learning process. This feedback should include verbal recommendations [Saphier, 2005] or encourage the students to reflect on their own learning processes [Hodgen and William, 2006] or discuss ideas with classmates; (4) encouraging the students to take responsibility for their learning processes, and (5) cooperative work. Slavin et al. (2003) showed that students mutually operating as learning resources benefited more when it came to understanding the learned topics. However they said that two conditions must be fulfilled: the learning environment must provide the learners with group aims, and each learner needs to have a sense of personal accountability toward his group.

In fact, the assessment method which we employed in the present study took into account these five strategies. We will broadly refer to them later.

PEER REVIEW IN HIGHER EDUCATION

Peer review is a form of external evaluation carried out by professional colleagues. Peers can be experts in the field but can also be classmates who assess the work of other students. Peer review is a widely practiced form of certifying quality in higher education [Herndon, 2006]. Peer review has been described as a formative evaluation process in which participants work collaboratively to strengthen a product [Keig &

Waggoner, 1994]. Peer review is generally said to encourage critical examination, promote the exchange of ideas, reduce non-academic interference, guide academic discourse, and reinforce academic values [Berkencotter, 1995]. Peer review assumes the existence of norms by which a peer's work may be judged. Through critical examination, norms are used to compare a peer's work to accepted practices. If a peer's work deviates significantly from accepted norms, then an attempt to correct it will likely occur. In reviewing the literature regarding peer review we found that it is mainly used in higher education for evaluating various processes such as the awarding of research funds, evaluating academic publications, reviewing faculty performance for tenure and promotion, and granting regional and disciplinary accreditation [Herndon, 2006]. Being aware of the advantages of peer review, we decided to incorporate it as an integral part of the assessment process in the workshop, since we believed that engaging the students in peer review might enhance their learning abilities.

MAPPING LEVELS OF UNDERSTANDING – THE SOLO TAXONOMY

The ever-increasing need for IT specialists to be capable of solving various business and societal problems requires a more constructivist approach. The preferred learning method is not memorizing content, but understanding principles and applying them in other contexts [Bloom, 1956: Biggs and Collis, 1982]. The SOLO taxonomy defines five levels of understanding applicable to learners in academia:

Pre-structural	The student lacks the ability to perform the task. There is insufficient understanding.
Uni-structural	One of a few aspects of the task to be performed is taken into account. There is some understanding.
Multi-structural	More aspects of the task are taken into account; however the student still lacks the "full picture."

Rational	All aspects are understood and integrated as a "whole." The student exhibits understanding of the pieces, as well as the relationships between them.
Extended abstract	The whole derived at the previous level is conceptualized at a higher abstract level so that it can now be used in different settings.

It was suggested that the SOLO taxonomy is a hierarchical model, suitable for measuring learning outcomes of different subjects, levels, and for assignments of various lengths [Biggs and Collis, 1982]. We used the SOLO taxonomy due to the objective criteria it provided for measuring students' cognitive attainments [Chick, 1998], which is in line with the workshop structure. The students' knowledge and understanding, during the workshop, was accrued incrementally, similar to the taxonomy.

IV. THE STUDY

ABOUT THE STUDY PARTICIPANTS

The systems analysis and design workshop's general objectives are to prepare the students for their Final Project and the real world challenges they will face. The workshop is a mandatory course taken during the third (and last) year of their studies. At this stage the students have a good understanding of the technical knowledge areas required for the workshop (software engineering, software modeling, UML usage, etc.), however, most of them still lack the non-technical knowledge areas (such as critical thinking and abilities to provide meaningful and helpful feedback). For that reason, the workshop that augments knowledge and understanding gained in current and previous courses is practical, "hands-on," and team based. There were a total of 35 students in the workshop forming 8 teams (5 teams of 4 students and 3 teams of 5 students).

THE COURSE

Each team received and worked on its own "story." A story was a general description of a virtual customer and a business case. The students had to study their story, address the problems presented in the business case and suggest ways (and a software based system) to solve the problems and achieve the customer's goals (which in many cases were not defined). The workshop structure was based on incremental assignments that follow the software development life-cycle. For each assignment the students had 2-3 weeks in which they worked together, used various collaborative tools, and consulted the instructor (via email, the workshop web site, and personal meetings). The workshop requirements included two types of deliverables (assignments): (1) team assignments, and (2) personal assignments.

TEAM ASSIGNMENTS

During the workshop there were three types of team assignments: (1) compiling four documents; (2) reviewing four documents (which were prepared by other teams), and (3) preparing and delivering a class presentation.

Compiling the Documents

The four documents submitted were: (1) project initiation and planning; (2) system analysis; (3) system design, and (4) system implementation. Each one of these documents had to follow a template which was provided in advance and posted on the workshop web site. In addition, for each template, a consistent grading guideline was provided. These guidelines outlined the relative grade assigned to each paragraph in the document. During the documents' preparation, the students had to consider the various issues related to their project, debate among themselves, and present the agreed upon solution.

Reviewing Documents

Each team's submitted document was reviewed and assessed by another team, based on the document template and grading guidelines that were

provided. This team-based peer review enhanced the students' critical thinking capabilities as well as their required soft-skills [Covey, 1996]. Working effectively as a team member is a vital skill for Information Systems graduates and is one of the objectives of the workshop. The team based review requires that members have good communication skills, including the ability to give and receive constructive criticism. The review process started with individual reviews followed by a team collaborative meeting in which they had to reach agreeable assessment. In the process of reviewing documents prepared by different teams, the students were exposed new possible solutions.

Presentation

The presentation was a summary of all the team work performed. While all team members had to participate, the grade was given on a team basis. This was done to stress the collective aspect of the work and to raise each member's personal accountability. The presentation started with a brief description of the virtual customer, the business case, and associated problems. The main part of the presentation was a description of the information system proposed as a solution. In addition, the presentation related to risks associated with the project, the expected benefits, the timeframe, and preliminary cost estimates.

PERSONAL ASSIGNMENTS

The personal assignments consisted of two parts: (1) reviewing, assessing, and evaluating the presentations given by all other teams, and (2) preparing a personal report to reflect a student's thoughts about the work performed and the workshop itself.

Evaluating Presentations

The evaluation form, available on the workshop web site, provided guidelines for the presentation. Every student assessed the presentation as if he or she were the customer. The main questions addressed the proposed solution and whether it convincingly solved the problems raised. The evaluation related to the team as a whole and the evaluating student

had to provide an average for the team members' performance. Presentation skills (as well as technical skills) varied among the team members; however, it was their responsibility to rehearse as much as needed, so that the team-made presentation achieved the required outcome.

Personal Report

Each student prepared a personal report which consisted of several issues: (1) feedback on the proportional contribution of each of the other team members. This feedback was used to assess the distribution of work among the team members, taking into account the team member's point of view. (This feedback also provided socio-metric data, which was interesting unto itself, but is beyond the scope of this paper.); (2) reflection on the work done by the team and by the student as part of the team, with special emphasis on the new experience gained by the individual student, and (3) reflection on the workshop as a whole, relating to benefits as well as suggested improvements.

THE WORKSHOP GRADING SCHEME

Each submitted document was reviewed and graded twice: once by the instructor and once by another team. Both assessments and grading were performed based on the common grading guidelines available on the workshop web site. The assignment grade was calculated using a weighted average, in which the instructor's grade weight was 80%, while the team's grade weight was 20%. However, this average was calculated only if the difference between the two grades was less than 16 points. If the difference was above 15 points, the students' evaluation grade was not taken into account in determining the submitting team's grade. Use of grading template served to enforce habits of precise and thorough analysis of documents, and to eliminate cases in which a team tried to improve the grades of a fellow team.

In addition to the assignment grade, each team was also graded for their review and evaluation of the other's documents. This grade was calculated based on difference between the instructor's grade and the

team's grade, and on the quality of the judgment processes expressed by the students and the feedback they provided in their review. The presentation prepared by the team was graded as well and this grade was mainly based on peer review.

V. LEARNING PROCESS EVALUATION METHODOLOGY

The workshop was highly structured. All documents submitted had to follow well defined templates and grading schemes. The fact that each document was graded twice (by the instructor and by another team), provided a framework for a simple learning process evaluation. Under ideal conditions, the instructor's grade should be identical to the evaluating team grade. If during the course of the workshop, a pattern of convergence emerged, it implied that learning occurred. For each of the documents submitted, the difference between the instructor's grade and the evaluating team grade was calculated. Based on the differences, a class average per assignment was calculated. It was quite simple to track the learning patterns of each team. However, one should take into account that (unfortunately) not all teams possess high cognitive levels. Learning patterns for such a team was somewhat limited. For that reason the class average was used. This average was very general, but provided the true picture.

VI. RESULTS AND DISCUSSION

In what follows we discuss the effect of the FA (Formative Assessment) the students were engaged in during the workshop on the gap between the instructor's grades and the reviewing teams' grades. In addition we present some of the students' reflections which shed light on their perceptions regarding their engagement in FA during the workshop.

THE EFFECT OF ENGAGEMENT IN FA ON THE GAP BETWEEN THE INSTRUCTOR AND THE STUDENTS' GRADING

Analyzing the difference between the instructor's grades and the teams' grades revealed that the numbers converge. The initial class difference average was quite low (less than 9 points), which can be attributed to the

workshop structure, the fact the grading was based on identical guidelines, and that the students assimilated the evaluation process. After the fourth assignment the average difference was reduced to 6 points (Figure 1). This pattern of convergence implies that the students learned to evaluate. However, taking into account that these are complex evaluations that require addressing and analyzing many different variables (the virtual customer, the presented "story", the business case and its problems, system analysis principles, the document being evaluated, etc.), good evaluations are possible only when the evaluator get to the extended abstract level in the SOLO taxonomy. In this case, the convergence is actually a learning demonstrator.

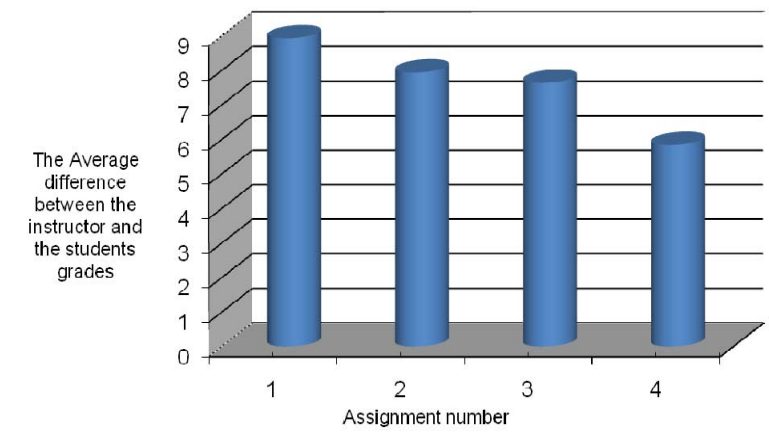

Figure 1. Average Grade Difference

The assignments in the workshop related to the higher levels of the SOLO taxonomy [Biggs, 1996; Biggs and Collis, 1982] - level 4 (Rational) and level 5 (Extended Abstract). Each submitted document was a unit that integrated knowledge and understanding about these aspects and their relationship. Each team got its own general "story." To understand the customer and the business circumstances, the students had to assimilate the ideas presented in class and apply them to the new situation. When evaluating and grading a document, the students had to exhibit the Extended Abstract level. This entailed understanding the whole solution

presented by their fellow students, conceptualizing it, and applying it to different situations. Several times during the workshop, some teams asked permission to modify their solution presented in the submitted document. The reason behind this ‘odd’ request was that during their evaluation of a different document, they realized they could improve their solution. This strongly supported SOLO taxonomy level 5 where a generalized abstraction reflected on oneself:

> 'Metacognitive understanding, students able to use the taught content in order to reflect on their own teaching, evaluate their decisions made in the classroom in terms of theory, and thereby improve their decision making and practice'. [Biggs, 1996]

THE EFFECT OF THE FORMATIVE ASSESSMENT FROM THE STUDENTS’ PERSPECTIVES

Analysis of the students’ reflections revealed that the students referred to three main issues: (1) the advantages and shortcomings of team-based peer review; (2) the effect of the assessment process they were engaged in on their performances, and (3) appreciation of the contribution of the workshop’s assignments to future employment.

Team-Based Peer Review

Students pointed out several advantages regarding their experience of team-based peer review during the workshop. Here are some of the common reflections:

> "I personally, learned many things, especially from what my team members did as well as from other students in the document they prepared (and which we evaluated)."

> "Team work, both doing the assignments and evaluating other group work, is very important. We had cases in which the amount of coordination between the team members was not sufficient, and it was noticed in the resulting documents submitted."

> "In the beginning we had some team problems (it took time before we learned how to work as a team), but by the end of the workshop it was much better."

> "The methodology used was very good. Working in teams provides solutions that one person, sometimes doesn't see and the other teams' evaluation is very important and helped us design a better solution. The review we received from other teams (and the instructor) provided additional important knowledge."

From these reflections we can learn that in general the students found the teams work method helpful in developing critical thinking and in improving their competencies to cooperate. This is true for both doing their project and evaluating other team's work. They also commented on the need for basic preparation before engaging in team work and referred to one of the most prominent advantages of teamwork – the combining of cognitive abilities. Team-based peer review helped them design better solutions. Our results are consistent with Berkencotter[1995] saying that peer review encourages critical examination, promotes the exchange of ideas and guides academic discourse. However, in their reflections, our students also pointed out shortcomings regarding their experience in team-based peer review. For example:

> "Working in a team was very difficult. The work distribution was not identical."

> "In a few cases the team members did not achieve cooperative working for various reasons and as a result, some had the feeling they had to work more than other team members – which caused frustration and tension."

THE EFFECT OF THE ASSESSMENT PROCESS THEY WERE ENGAGED IN ON THEIR PERFORMANCES

Some more student reflections:

> "Working in a team was very helpful. It would have been impossible to successfully complete the workshop without the comments and helpful suggestions we received from other reviewing teams."
>
> "I've learnt a lot from analyzing other student documents."
>
> "The workshop helped me understand better. The 'customer' interview and the feedback we received proved to be extremely helpful. Only after carefully analyzing these comments, did we really understand how much we missed in our original thinking."
>
> "The workshop taught me about the proper way of developing projects. The comments provided additional insight on the process."

From the above students' excerpts we can conclude that the students developed a sense of appreciation for the feedback (formative assessment) contribution they received from other teams. They said the feedback raised their awareness to various nuances of the given tasks and as a result helped them reach better solutions. Using the SOLO taxonomy [Biggs, 1996; Biggs and Collis, 1982] notations, the feedback helped the students move from the Multi-structural level to the Rational Level. The students themselves agree that the peer-review mechanism provided additional aspects they originally missed. The fact that they realized, for example, that the first document was not good enough, reflects understanding that they lacked the 'full picture.' These results are consistent with Williams (2001) stressing that through the use of pair-programming the students no longer view the teaching staff as their sole form of technical information.

In some of the above reflections, the students said the other teams' feedback helped them a lot but they did not specify in what ways. They also referred to the effect the feedback they gave to the other teams had on their own performances. This was mentioned in regards to the team work; however, it reflected the understanding that for reviewing, analyzing, and evaluating other teams' documents an integrated team based

approach was needed. Once again, team based work helped students move to a higher level on the SOLO taxonomy.

APPRECIATION OF THE CONTRIBUTION OF THE WORKSHOP'S ASSIGNMENTS TO FUTURE VOCATIONS

Here are some student reflections regarding the contribution of the workshop's assignments to their future employment.

> "The workshop and the submitted documents prepare us for the 'real world.' I personally work in industry and can state that the quality of the documents submitted are by all means equivalent (if not better) than what I am used to at work."

> "The workshop provided excellent experience for the final project we have to develop as well as preparation for the real world. It provided significant knowledge required in the future."

> "Working on an imaginary project is difficult. It is easier to work with a 'real' client. Some of the requirements were not clear, but the feedback we got helped us understand. The important thing we learned is that defining the system and its requirements is a complicated process."

We conclude that the students found the detailed documentation very helpful. The various templates of assessment forms for each task helped them think as developers and enhance the process of the problem solution.

Regarding the effect of their engagement in the workshop on their future vocations, the students found that the workshop's process provided significant knowledge they would need in the future. Even students already working in industry felt they learned from the workshop and said that they will use the acquired knowledge in their current work.

CONCLUDING REMARKS

From the students' reflections and the results received regarding the gap reduction between the instructor and the students' grading, it can be

concluded that the engagement in FA during the workshop, the giving and receiving of feedback, raised the students' levels of understanding [Biggs, 1996] and as a result helped them cope successfully with the given workshop assignments. Using the SOLO taxonomy increased their level of understanding and as a consequence their performance of the given tasks. Functioning as evaluators of other teams exposed the students to various ideas different from the ones they decided to use in their solutions. This exposure, in many cases, made them rethink their task and prompted them to look for better or more efficient solutions. The collaborative team work exposed each team member to various ideas expressed by his/her friends and as a result caused additional thinking about available solution alternatives. An additional effect of the peer review FA was that the students no longer viewed the teaching staff as their sole source of technical information [Williams, 2001].

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