J. Comp. Sci. Comm., 1(2)32-37, 2015
ISSN 2356-8844
Journal of Computer Sciences and Communication
www.textroad.com

Using the SOLO Taxonomy to Observe Effectiveness of Innovative Learning and Teaching Technologies

Saleh Alshomrani[1], Abdulrahman Altalhi[2], Gulraiz Iqbal[1]

[1]Department of Information Systems, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia
[2]Department of Information Technology, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia

Received: February 7, 2015
Accepted: April 1, 2015

ABSTRACT

Educational research findings suggest that adopting the technology in open, distance and face-to-face (FTF) teaching encourages instructors and learners to participate in active learning process. To attain Intended Learning Outcome (ILO) they evolve each other by challenging & arguing, investigating problem domain, using critical reasoning and doing experiments. The whole process helps them to obtain ILO by avoiding misconception, self-assumed theories and practices. Numerous smart technologies (e.g. clickers, SMART boards, video projectors and CMS) are currently used in modern classrooms. Such technologies enhance the capability of modern classroom environment and help to equip instructors with useful simulation tools. The main challenges for educators are to engage students of different abilities within same class in active learning process and to analyze the student understandings. Whereas, choosing the best technology for the classroom is difficult because such tools having limited features and do not supports flexible questions such as free text questions. In this paper, we review the literature; analyze affectivity of adopting technology, developed active SRS app (android client / desktop server) and presented results using SOLO taxonomy of cognitive development as a guide to make quantitative assessment.
KEYWORDS: Interactive learning; Assessment; Simulators; Innovative teaching style

I. INTRODUCTION

For centuries, delivering lectures are the most popular pedagogical methods for transferring knowledge. Modern classrooms are equipped with latest technological tools to support class instructors and learners. The common approaches used in active learning are peer instruction, just in time teaching and Socratic learning method(Lasry et al., 2013, Bray, 2012). Using these approaches in the classroom teaching help instructors to avoid misconception caused during transfer of knowledge by misunderstanding the instructor guidelines, reading textbooks and articles. A handy question can read the mind of a learner, therefor instructor allows learner to demonstrate their key concepts by answering a question. Research statistics indicate that the use of the technology in a classroom improves student's performance. Eric Mazur describes the active learning as(Lasry et al., 2013), "The trend toward active learning may overthrow the style of teaching that has ruled universities for 600 years" [Harvard Magazine "Twilight of the Lecture" May-June 2012]. To make sure that the learners are getting the concepts and they understand the foundations of the course delivered in the classroom, he introduced two key approaches 1. Peer instruction (PI) and 2. Just in time teaching (Lasry et al., 2013, Crouch and Mazur, 2001). Peer Instruction, used by higher education institutions and recommended for various disciplines around the globe. PI is a well-known approach for knowledge transformation and integration. PI is also recognized as student centered approach where information is transferred in traditional classrooms through innovative technologies. During lecture the learners are asked to revise, defend their concepts by answering question, as they are allowed to discuss these with their peers. The results suggest that student centered approach is more useful over traditional teaching methods (Lasry et al., 2013, Crouch and Mazur, 2001, Beth Simon, 2010). Whereas, Just in Time Teaching which helps learner to participate actively in the classroom activities where learners have prior acknowledgment about (Homework assigned or guidelines published) class activities and instructors planned the activity. Learners are free to preconceive the concepts by reading textbooks, using internet, or by reading instructor led material (Lasry et al., 2013, Crouch and Mazur, 2001). Socratic and Inquiry based learning method are an effective teaching and learning approach that promotes active learning process by focusing on student's engagement on critical thinking. This approach is also known as "dialectical" because it allows instructor and learner to identify and correct the misconception or misunderstanding. This approach leads towards reliable knowledge construction and independent thinking. Socratic questioning is helpful in teaching process as it force students to focus explicitly on the process of thinking(Berking, 2011, Bray, 2012).

***Corresponding Author:** Saleh Alshomrani, Department of Information Systems, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia. Email: sshomrani@kau.edu.sa

Generally, two type of assessment techniques used to evaluate student progress(Buick, 2010). Open-Ended Questions (OEQ) is an effective method that is used by instructors to understand learner's thinking that involves posing questions and require learners to think. It presents useful reasoning to prove an understanding of the concepts being taught. Usually such scenarios do not have a fix predetermined answer. The technique is useful when knowledge is delivered and questions are prepared earlier then class time, which is a part of planning process. Close-Ended Questions (CEQ) are common types of multiple-choice questions or true / false questions, which are very restrictive. It involves posing questions in short time and assessing the knowledge domain very quickly(M. K. Smith, 2009). Learners are not assessed, based on formulating their answers. To assess thorough knowledge, short question must be worded carefully to increase the accuracy of assessment. Short question may also encourage rote learning. Whereas, educational taxonomies are convenient tool, commonly used to develop learning objectives and assessing student attainment. Bloom and SOLO taxonomy are widely used in the design, develop and assessment of course. These taxonomies are generic and strongly rely on assumptions and hierarchy of learning process, which is same in all subjects. Reviewing literature, we found the facts that (Jacqueline L. Whalley, 2006) applied Bloom and SOLO taxonomies to analyze the results of programming exercises. Number students carry out solved exercises where different type of questions such as multiple-choice questions (CEQ), free-text questions (OEQ) were included. The conclusion extracted from this research is that is the difficulty of multiple-choice questions to correlate strongly with their placement on the taxonomies.

The paper is organized into five sections. First section presents a detailed introduction to innovative teaching, intended learning outcome, assessment using SOLO taxonomy(Clark, 2014). Second section based on our methodology and third sections briefly describes experiments. Fourth section, analysis and discussion on results extracted by using active SRS. Furthermore, the assessment tools available from earlier findings and objective of tools like SRS to use them in classroom lecture and discusses assessment techniques and type of questions based on existing research work. Whereas SOLO taxonomy of cognitive development is presented in the guide form and its various levels are discussed. Finally, in the final section, future directions are presented in the form of innovative teaching and learning on large-scale.

II. METHODOLOGY

In yearly report of EDUCAUSE (data collected), it is a report that 64% of students from US, Canada and other countries strongly agree / agree that use of technology in classroom and virtual environment teaching styles boost the level of teaching(Susan Grajek, 2012). Research suggests the utilization of innovative technologies for teaching prospective helps students to learn and share ideas (Tena B. Crews, 2011). This study has found the evidence that features offered by clickers and web / mobile SRS are very attractive and efficient but costly (Freeman et al., 2014). Whereas clicker SRS devices are not easy to handle. Distributing and collecting back from student is a major issue, which demand extra responsibility to handle devices. Teaching students of different abilities in same class is a difficult task. It is very important that teacher must be familiar with the level of students in the classroom to pay attention on weak areas of skills (Leo Porter). Using technologies like clickers helps instructor to recognize the diverse learner in face-to-face and distance learning classrooms. Other classroom technologies such as SRS, DMS (Document Management System used to handle documents related operations). Whereas, Blogs (commonly use to listen and share thoughts views and experience) and Wikis (collection of pages that enables everyone to contribute or modify the contents) have a direct impact on learning process and research indicates use of technologies helps learner to move quickly from lower level (U and M) to upper level (R and E) of taxonomy. Educational researchers have developed a range of TLE and taxonomies that helps educators to develop learning outcomes, educational resources and assessments. In this research, we reviewed TLE environment by using SOLO taxonomy to categorize the quantitative and qualitative difference on student performances.

			Classroom Technologies (Observing Learning Outcomes)			
SOLO Taxonomy	**Learning**	**SRS**	**DMS**	**Blogs**	**Blended Learning**	**Wikis**
P	Misconception	√	√	√	√	√
U	identify at least one relevant aspect	√	√	√	√	√
M	Enumerate	×	√	√	√	√
R	Integrate into a structure	×	√	√	√	√
E	Generalize to new domain	×	×	×	×	×

Table 1. Observing Performance of Instructional Technologies in Higher Education Institution through SOLO Taxonomy(Ursula Fuller, 2007)

Increasing complexity in learners understanding goes through five cognitive development stages. There are clear links with classroom technologies and conceptions of learning where classroom technologies provide support to embrace previous levels and move to the next level. In the following Table 1, we evaluated learning outcomes and the learner using classroom technologies can obtain possible classification level. Listed classroom technologies providing support to achieve different level of SOLO taxonomy.

As shown in figure 1, active SRS is a client / server application. Server side is programmed using java socket, swings and j Free Chart framework (Gilbert, 2014) for visualizing data. Whereas android framework is used for client side programming. During data collection and active learning process, server side work purely handled by class instructor. Class instructors created questions by considering SOLO taxonomy levels (Clark, 2014). All clients connected using host address and host port which are generated by active SRS server. As the class instructor open the question from active SRS server, all information (open question and choices) required by client to get response from clients. Connection manager from client / server side is responsible to keep client / server alive during the whole process. Active SRS server collected all responses and generated valid results for the instructor on the spot. Few miner bugs were reported during data collection but it is learnt that such bugs have no effect on data collection process. Responses from intended clients were successfully collected.

Figure 1. active SRS Client / Server Application

III. EXPERIMENTS

In this paper, we developed active SRS to collect student responses and presented initial results from one semester in two programming course at King Abdulaziz University (KAU). During classroom teaching, instruction model strictly followed by programming instructors. Figure 2 elaborates the instruction model having four levels of the process. Level 1 is lecturing and second level of model is posing question on student and later recording all answers to evaluate the level of understandings. After collecting response, a detail in-class discussion carried out whereas instructor encourage student to discuss all the significances question asked and topic studied.

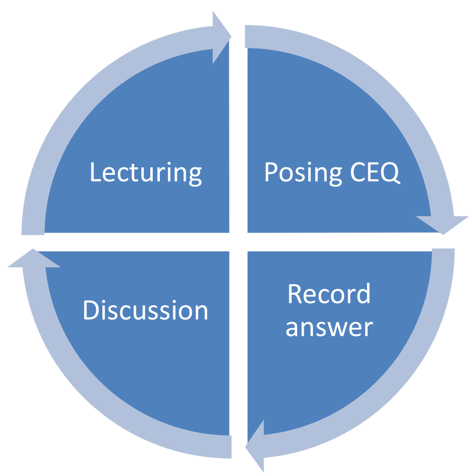

Figure2. Classroom Instruction Model

During the whole semester, 40 questions were asked using active SRS and responses collected from 100 students. All the tests were CEQ's (30 questions were multiple-choice questions and 10 short-answer questions).The research team designed all type of questions, using the SOLO taxonomy, to evaluate the program comprehension and learner progress. We used active SRS framework to collect student response. The active

SRS is a client / server application developed to collect student in-class response. After having healthy debate on a topic, instructors open the questions from active SRS desktop application and start collecting response from students. After collecting results from students, instructor visualize the results to evaluate the students understanding during current session. Instructor has a number of correct / incorrect responses that helps him to estimate the number of students missed-conceive the knowledge. The results generated by active SRS helped instructor to understand that learner misunderstood the discussed topic and required to repeat a particular topic in the class or required more discussion.

The data collected during the study, consisted of student answers to 40 CEQs. All questions were categorized to determine the student knowledge. Level one Uni-Structural (U), questions were asked during first four weeks of the semester. Knowledge level of all learner was assumed limited. They were asked simple and easy questions during this phase of data collection and domain of the questions was very limited. In level two Multistructural (M), where learner have basic knowledge and focuses on several key and relevant aspects. Medium level of questions were asked during next four weeks of the semester. In relational (R), an acceptable understanding of subject achieved by integrating all different aspects into a coherent unit and joining all the parts together. It indicates that learner has a thorough and deeper understanding of the subject. Comparatively complex questions were asked during final phase of data collection. In last, data of successful students in all type of exams during whole semester is collected.

In order to investigate hypothesis, we further reviewed studies in education research and TLE. During the investigation, we found many useful software environments accompanied with a device commonly known as clickers (Message Grid (Pargas, 2006), concept Text/clickers (Tena B. Crews, 2011), socrative (Socrative, 2014 #29), Quizdom Actionpoint (Qwizdom, 2014 #28)),many researcher used them to collect student response as well teachers use them to assess learner's knowledge and understandings. Such tools are providing limited features.

IV. RESULTS

Figure 4.2 shows histogram for responses collected by active SRS. Correct responses (blue), incorrect responses (dark red) and difference (green) are expressed as a percentage of all responses over all the active SRS questions posed during the semester. The figure 1 shows the ratio of correct to incorrect responses plotted as a function of the percent of students in class who have responded to question posed on them. All the responses were categorized to three levels of SOLO taxonomy to examine the performance of the student at different levels. Results displayed in the figure above showing that as students are moving from basic questions to difficult misconception tend to increase. Comparatively results percentage is better in U and M level of taxonomy and low percentage of incorrect responses were recorded. Where as in R level of taxonomy percentage of incorrect response is five time more than U and almost three times higher than M. The lesson learnt from the result is as the student are asked complex questions and moving to gain depth knowledge of topic, misconception tends to increase. The difference among easy, medium and hard questions is positive. Error bars represents the standard error of the mean across each ratio.

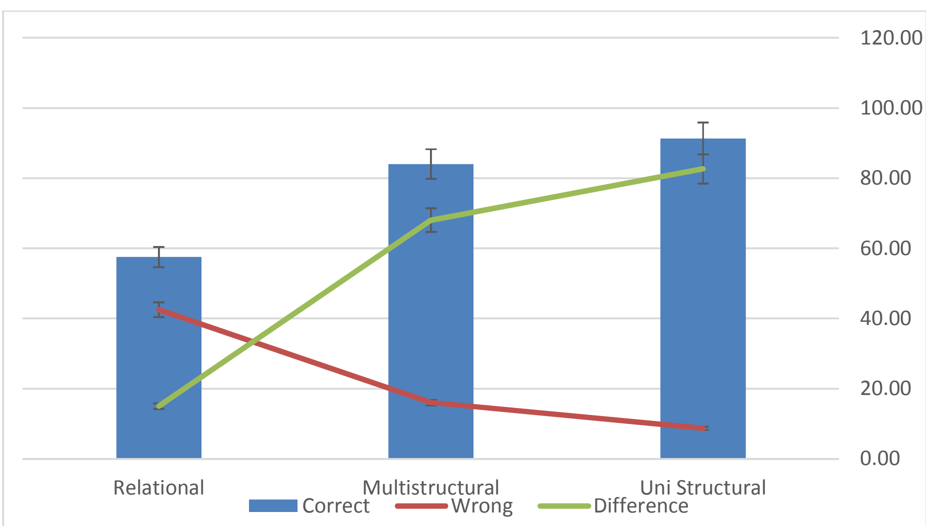

Figure 3. Learner Performance by SOLO's category

In assessment, SOLO taxonomy used as a mechanism for holistic marking. However, (John Biggs, 2007) discussed few examples of assessment strategies targeting the items at specific SOLO levels, even more holistic marking strategies. The upper level of SOLO taxonomy emphasis on integration and extension of principles demanding a broader level of attributes to be examined, whereas lower level of SOLO taxonomy (U and M) can be used to focus on stand-alone attributes or items. Cognitive processing level better involved in R and E than in Pre-structural (P) and U because the learner have to recall the items as well establish the relationship among items (R) and draw conclusions Extended Abstract (E). Figure 4.a showing correct responses reported and in figure4.b showing wrong response reported.

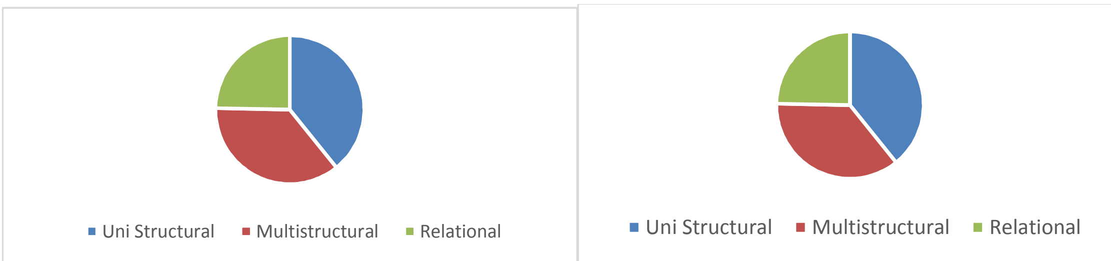

Figure 4 (a)&(b)Learner correct and incorrect responses by SOLO's category

V. CONCLUSION AND FUTURE WORK

The active SRS application is very handy to use in classrooms and was able to generate results quickly. We collected data from two different programming courses using active SRS, we found very interesting results from analysis of response against questions posed during classroom. In U and M level of SOLO taxonomy correct responses ratio is higher than level R where questions asked were more complex were asked. Therefore, misconception is very low in start of the course when fundamental concepts were discussed. Whereas, results collected after mid shows higher level of misconception. Additionally, using SOLO taxonomy to analyze student performance based on active SRS assessment during lecture. We found that these technologies are ineffective to assess level of student understandings. Misconception is common among the student when logical and complex questions are asked from the students. It is hard to determine the level of understandings through CEQ and existing classroom technologies and active SRS supports CEQ. It is also learnt that active SRS encourage learners to participate actively in class sessions (FTF, distance learning and open learning), which help them to improve their skills and enhance the learning capabilities.

In future, active SRS and other classroom technologies must provide additional support such as OEQ and integration with learning platforms. Using OEQ approach in classroom teaching is more successful than CEQ. In addition, it is important to investigate the reasons of common misconceptions, misunderstandings complex questions, reasons of random guessing and evaluating the response time.

ACKNOWLEDGMENT

Authorship team would like to thanks to M. Ali for his support in data collection phase. All authors revised the work and approved the final copy of the manuscript.

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