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Theme V: Quality Issues in Innovation & Creativity.

The Role of Formative Assessment in Teaching Mathematics

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Abstract: The progress of mobile and wireless communication technologies has encouraged an increasing number of studies concerning formative assessment using mobile learning, in which students are able to learn mathematics via mobile devices without being limited by space and time; in particular, the students can be situated in a real-world scenario associated with the learning content. Although such an approach seems interesting to the students, researchers have emphasized the need for well-designed learning support in order to improve the students' learning achievements using mobile devices as a resource for doing formative assessment. Therefore, it has become an important issue to develop methodologies or tools to assist the students to learn Mathematics in a mobile learning environment with formative assessment. Based on this perspective, this study proposes a formative assessment-based approach for improving the Mathematical learning achievements of students in a mobile learning environment.

Keywords: Web based systems, Formative Assessments, Teaching Mathematics, Mobile Technology.

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*1-Introducti*on

For centuries assessments were seen as a way to find out what students have learnt. However towards the end of the century, researchers began to look at assessments more systematically and also at the role it could play in enhancing the learning rather than just measuring it Research shows that teaching is more effective when it assesses and uses prior learning so that the teaching may be adapted to the needs of students (Black & Wiliam, 1998).

Assessment is one of the most important tasks in the learning process. Its aim is to determine if the student has achieved the objectives of the course.

It helps in diagnosing the difficulty in learning; it also helps to motivate students and assess teaching methods. There are two types of assessment, summative assessment and formative assessment.

Summative assessment; records over all achievements at the end of a course and evaluates students learning when the course is completed by comparing their work against some benchmark (examples midterm, project), it does not consider the learning process or how the student has acquired their knowledge On the other hand, **formative assessment** emphasis the learning process of the students rather than the final result, its goal is to provide ongoing feedback and to enhance students learning process. Furthermore, it helps teachers to improve their teaching.

Assessment is the heart of formal higher education, in fact assessment is the core component for effective learning (Bransford, Brown & Cocking, 2000) they indicated that teaching and learning process need to be assessment center to provide learners with opportunities to demonstrate their developing abilities and receive support to enhance their learning.

Online and blended learning have become a common place in 21st century higher education. A meta-analysis of online learning reported by the US Department of Education (2009) suggests that online instruction, in general can be more beneficial than traditional face-to-face.

There have been various definitions for mobile learning, such as "learning that happens without being limited at a fixed location" and "learning that takes advantage of mobile technologies". Owing to the popularity of mobile devices (e.g., mobile phones or Personal Digital Assistants, PDAs), most researchers have adopted the latter definition in recent years, as in for example, the studies of (Chu, Hwang, Tsai, & Tseng 2010).

Compared with traditional instruction or information from textbooks, mobile learning seems to be a more attractive way of learning that can trigger the interest and motivation of the learners. However, most of the previous studies mainly focused on the feedback from students concerning the use of mobile devices in learning, such as the acceptance of the technology (e.g., "ease of use" and usefulness of the mobile learning system) (Chen, Chang & Wang, 2008) and the students' interest or attitudes toward the mobile learning approach

(Chen, Kao, & Sheu, 2003), while the provision of methodologies or tools to improve the students' learning achievements still remains an important and challenging issue (Chu, Hwang, & Tsai, 2010; Hwang, Kuo, Yin, & Chuang, 2010a).

In this research we explore some popular web based systems that allow higher education students to do their homework, assignments and Quizzes online. We investigate the usefulness of some of these applications in obtaining formative assessment while solving math problems. Then we employ our research in two different math courses at Zayed University. At the end a survey is carried out in these classes, which helps us in reaching conclusion concerning the use of mobile devices in learning mathematics; such as the acceptance of the technology by students, their preference of using technology over the traditional method in solving math problems and to what extend it helped them.

Sections 2 and 3 deals with formative assessments, section 4 deals with online methods, while in section 5 we mention the methodology. In section 6 we review some web based systems. The result of research and survey is in section 7, in section 8 we mention the impact of this research on math teaching globally and we conclude with section 9.

2-The Need of Formative Assessment in Teaching Mathematics and it's Critical Aspects

"An assessment to enhance learning during learning is a formative assessment"

Benjamin Bloom took up the term in 1968 in the book Learning for Mastery to consider formative assessment as a tool for improving the teaching-learning process for students.

The term 'assessment' refers to all those activities undertaken by teachers and students in assessing themselves, which provides information to be used as a feedback to modify the teaching and learning activities in which they are engaged. Such assessments become 'formative assessment' when the evidence is actually used to adapt the needs of the learner.

Different approaches to formative assessment are underpinned by diverse philosophies, and this affects the assessment development and construction process. Authentic formative assessment is claimed to be closer to teaching and learning strategies and thus to deliver improved quality of information because the students are not placed in an unfamiliar situation. There is evidence that students perform differently on diverse types of tests, home works and quizzes (Caygill & Eley, 2001). Multiple choice questions leads to higher response, but how much formative these multiple-choice questions are? Is it possible to predict that a student who performs well on a multiple choice mathematics homework, will also perform well on a formative assessment questions demanding higher order thinking skills? Or vice versa.

Teaching and learning has to be interactive. Teachers need to know about their student's progress and difficulties with learning so that they can adapt their work to meet their needs, which vary from student to student. Teacher can find out what they need in a variety of ways, through observation, discussion in the classroom and from students' method of solving math problems.

This raises issues about the nature of the construct being assessed, and the choice of formative assessment method according to the information teacher wanted the students to learn. If higher order thinking is the target, then formative assessment should be designed to target that, if mathematical skills are the target, then this should be the focus (Shepard, 2000). Therefore, target need to be clarified before the formative assessment is developed.

3-Deploying Formative Assessment in Teaching and Learning Mathematics

In math education, it is really important for teachers to see how their students approach the problems and how much mathematical knowledge and at what level students use when solving the problems. That is, knowing how students think in the process of learning or problem solving makes it possible for teachers to help their students overcome conceptual difficulties and, in turn, improve learning. In that sense, formative assessment is diagnostic.

Deploying formative assessment in the classroom, means asking students to solve math problems in the classroom using skills that they have learned, while teachers monitor their progress. Deploying formative assessment outside classroom, means giving students home works and assignments, which they solve without teachers guidance or help. These assignments are corrected and a classroom discussion about their common mistakes is mentioned and this is the formative assessment.

Although this type of formative assessment is productive and helps students learn, but there are three points need to be considered:
- Teachers assessing students formatively in the classroom is good, but it is better if students are able to solve on their own without much guidance from the teacher, in another way to build their own confidence and skills on how to tackle the problem.
- Teachers assessing students formatively in the classroom, is too much time consuming of the class, as most of the cases; teachers strive to cover the syllabus of the course.
- Giving student weekly home works and assignments is productive when the teacher corrects it. The only drawback is that it is too much time consuming for the teachers, especially if they have large number of students in each class and many courses to teach.

4. Paradigm Shift from Traditional to online methods

Question raises to search for alternative method of carrying formative assessment, which is productive, produces feedback, enjoyable, exciting and beneficial for students to learn how to solve math problems without being limited to the classroom, and also it is less time consuming for teachers?

It requires educators to rethink online pedagogy in order to achieve effective formative assessment strategies that can support meaningful mathematics learning and its assessment.

In the past decade, many studies have demonstrated the benefits of web-based learning. Various learning methodologies or tools have been developed for enhancing the effectiveness of web based learning, such as assessment and feedback (Huang, Chu, Yin Lin, 2008). With recent advances in educational technology, teachers now have a multitude of tools to assist and enhance students learning and motivation. New intelligent tutoring systems that guide

students through math problems much the same way as human tutors do, have been successful in helping students learn math in the classroom.

Some systems attempts to imitate a human tutor by reproducing the interactive dialogue patterns and strategies that were likely to be used by a human tutor, whereas others provide immediate feedback by highlighting each step attempted to indicate right or wrong answer, - sometimes they provide hints sequence to students asking for help.

Key Components of Formative Assessments:
- The assessment should be learner friendly. It should serve the learner rather than the audience. The feedback should reach the student and help them understand the teacher's learning intentions and what constitute success, and provide them with opportunities to revise and improve their thinking and help students to monitor their own progress over time.
- It should be easy to use and understand by students
- It should make students thinking visible: I mean the assessment should reveal the background knowledge and the kind of conceptual strategies students use to solve problems
- It should be built on solid cognitive, developmental and educational research; in other words the assessment built this way help teachers ingrain research finding and ideas into their thinking as they interpret students behavior and develop an effective approach to instruction.

5-Methodology

Some of the popular web based systems that allow higher education students to do their homework, assignments and Quizzes online are, for example; Blackboard, Khan Academy, Web Assign, ASSISTment system, Mymathlab by Pearson and ALEKS by McGraw Hill Company. We explore some of these web based formative assessment applications and investigate the usefulness of these applications in obtaining formative assessment to our mathematics courses.

There are three main factors that play important role in our exploration of Web based formative assessment:
- The design,
- The role of the teacher
- The educational context.

The first factor concerns design: the design of corresponding tasks and activities, and the design of lessons and teaching in general, three design levels that are of course interrelated. In terms of the instrumental genesis model, the criterion for appropriate design is that it enhances the co-emergence of technical mastery to use the digital technology for solving mathematical tasks.

The second factor concerns the role of the teacher, which is crucial .The integration of technology in mathematics education is not a panacea that reduces the importance of the teacher. Rather, the teacher has to orchestrate learning, for example by synthesizing the

results of technology-rich activities, highlighting fruitful tool techniques, and relating the experiences within the technological environment to paper-and-pencil skills or to other mathematical activities.

The third and final factor concerns the educational context, it also helps us to know how important it is that the use of digital technology is embedded in an educational context that is coherent and in which the work with technology is integrated in a natural way.

Putting the three main factors into consideration when preparing math quizzes or home works for students using web based systems. We must realize our goals as teachers, which is helping students learn how to solve and tackle math problems. Therefore; in preparing the math questions we need to be able to write down questions and hints in a way that would help students in solving them. In other words, we need to think how would we tutor students to solve the problem? How would we break down the problem into simpler problems? What hints we would give students? What kinds of error are more common and are expected from students? What would we say to students when they make such error?

In our exploration for some suitable web based system for solving math problems, we put in our consideration those web-based system that grades the homework automatically. Basically, this will help teachers save grading time and also show students performance right away. Furthermore, the system must be user-friendly, for both teachers and students, for teachers so they can create questions easily and deploy it, and for students to be able to use it right away and benefits from the feedback.

6-Review of Some Web Based Systems

We investigate some web-based systems for solving math questions, putting in our mind the key components of formative assessment. There are two types of web-based application. Some web based application require students to purchase their text book, then they get access to their web based system, some require students to purchase license then register into their site to solve math problem. Those web based system are assessment and learning sites, they either don't have or have very limited option of writing our own math problems. Basically; we are limited to using whatever they have build in, they are very helpful for the students who are using their text books. In our investigation, we are more interested in the type of web-based system, which gives the option of building our own math questions according to the courses we are teaching.

In this research we explore, those web based systems that allow us to write our own math questions.

- Blackboard (www.blackboard.com), WebAssign (www.webassing.com),

Thousands of students and teachers around the world use these systems in their universities. These web-based systems are used for putting course material to the students and making announcement and posting their grades also for giving homework and test and students do their home works using it. Some of these give immediate feedback to students, does automatic grading and you can build your own questions.

When using it, students obtain immediate feedback, also it has option of auto grading and we can build our own questions, but questions are limited to multiple-choice type.

- The ASSIST ment System:

Assistance and assessment is integrated in a web-based system called the ASSISTment system, which offers instruction to students while providing a detailed evaluation of their abilities to teacher (Mendicino, Razzaq & Heffernan, 2009).

The design of the ASSISTment system was informed by earlier systems such as Cognitive Tutors (Anderson, Corbett, Koedinger & Pelletier, 1995) and Ms. Lindquist (Heffernan & Koedinger, 2002). These systems use "model-tracking" architecture that were invented by researcher at Carnegi Mellon University and used extensively to build tutors. In fact Ms. Lindquist was the first intelligent tutor that had both a model of students thinking and a model of tutorial planning. The ASSISTment system breaks the problem down to the students in a way that Cognitive Tutors and Ms. Lindquist do but it uses a further simplified example-tracking tutor that allows only linear progression through a problem, which makes content creation easier and more accessible to non-programmers.

When using, it students obtain immediate feedback, also it has the option of auto grading and you can build your own questions. Moreover, when writing question you can add the feedback you want.   It also has the scaffolding option, and you are not just limited to multiple choice but you have some other options too.

- JCALC system:

Is a mathematical learning software developed by Professor H. Yokota of Shibaura institute of Technology. It is great software, which seems very interesting, but we are still learning about it. (Yokota, 2009).

7- Research and Survey Result

The opportunities for students to do their homework online increase as the digital divide narrows. Few important questions come to mind; do students learn more by using Mobiles devices (web based system) to do their homework than doing it the traditional way of using pen and paper? which method they prefer more? And why?

To answer these questions; first we must keep in mind that pen and paper is a must in solving any math problem, even when they are using any web based system through their mobile devices or laptops.

We carried our research, of using web based formative assessments in solving math problems in two different math courses at Zayed University, two sections in an introductory level course basic algebra, and two sections in Mathematical modeling with functions, which is a first year course. A total of 90 students participated in our research.

When writing math problems using different web based system, we first need to learn the web system and also we need to educate students on how to use it.

The Diagnosis

- Decide which web based system to use
- Decide the type of problem:
  Putting in our mind what type of problems we would like students to learn solving them, then the process how the problems should break into simpler problems?
- If the web system has the option of providing hints to students when they solve wrong or the option of scaffolding the problem, then we write accordingly.

Design Strategies

When writing math problems using different web based systems, we first need to learn each one of these systems, after we decide which one to use we need to teach and educate students how to create password and enroll so they can solve online. Moreover, we need to give clear instruction on how to write their answers, if we are not using multiple choice type questions.

We have used more than one web based systems in our math classrooms and asked the students to solve home works and assignments using these web-based systems for more than one month period.

Developmental Outcome

At the end, when students were done doing homework and assignments using mobile devices for more than one month. A survey was given to students, which comprised following type questions:

Did student feel that web-based system is user friendly, did solving math problems using mobile technology, which is not limited to a place, made them more excited and helped them when teachers are not around, how much was the feedback helpful for them. The survey also illustrated on how many students preferred the web based to the traditional way of using pen and paper?

Result:
Result of Basic Algebra Course

| Question	% Satisfied	% Neutral	% Not satisfied
How many students felt web system is user friendly	25%	54%	21%
How many felt excited and enjoyed solving math problem using web system	16%	52%	32%
How many students benefited from the feedback and hints when solving math problem	50%	33%	17%

Result of Mathematical Modeling with Functions course

Question	% Satisfied	% Neutral	% Not satisfied
How many students felt web system is user friendly	53%	44%	3%
How many felt excited and enjoyed solving math problem using web system	76%	12%	12%
How many students benefited from the feedback and hints when solving math problem	83%	12%	5%

The next question shows student's preference between web based or traditional method for solving math problems

Course	Web based system	Traditional way
Basic Algebra Course	11%	89%
Math Modeling with functions	58%	42%

Below is a Pie Chart showing the above result of comparison:
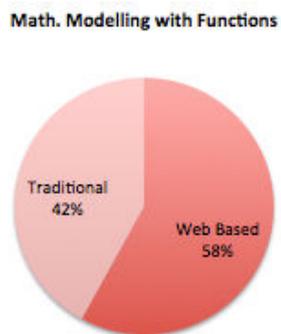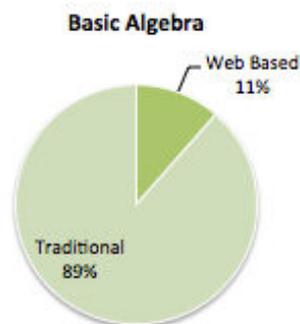
The survey result differs greatly between the two courses. One of the reasons is that Basic algebra course is taken by students who are freshmen, first course in the university after high school, English being second language of instruction also they lack much familiarity with the use of mobile devices for learning or solving math.

On the other hand, the Mathematical Modeling with Function course is their third math course in the university and by that time they are more experienced to use mobile devices.

Advantages and disadvantages of using Web Based System To Learn Mathematics:
We gained experience after we have tried several web-based systems in math courses. Moreover, the survey and students comments helped us list some of the advantages and disadvantages of using web based system:

Advantages	Disadvantages
Some systems give immediate feedback and hints that helps students, when they solve math problems on their own.	It is difficult to look at students work as the options restricted to only multiple choice and fill in the blanks.
The feedback and guidance is not restricted to the classroom, they can solve these problems at home or any other place using their mobile devices.	While solving the question of format fill in the blanks the answers are expected to be exactly as written by the teacher, students don't even have the option of rounding the answer.
Some systems automatically grade these problems, therefore saves teacher's time.	Screen of the mobile devices gets freeze and sometimes WIFI issues are also important.
Students enjoyed using their mobile devices to solve problems, as this new generation is a gadget generation, so for them it was exciting, fun filled and something new that they did not experience before.	After submission they do not have access to see the work done by them.
During off campus when they cannot see their teacher and they want to practice more math problems or prepare themselves for the test, the web based problems helps them to learn as the feedback and hints guides them.	Some students forgot their user name and password so they had to make new accounts on the web site, unfortunately they could not continue on the same set of problem, which they solved, they had to start all over again.

8-The Impact of this research on Mathematics Teaching Globally

No studies has been carried out in UAE or in the Arab Gulf region in this area, it seems very interesting for us to conduct such a study in UAE. Our result might help other GCC countries to think about adopting the formative assessment concept using mobile technology in teaching mathematics.

Meta-analysis of studies into formative assessment have indicated significant learning gains where formative assessment is used, across all content areas, knowledge and skill types, and levels of education.

All teachers wish for their students to become engaged, successful, and enthusiastic learners, and teachers often make observations such as this:

We want students to take responsibility for their own learning and be active learners.
Teachers and researchers alike recognize that, students who can monitor and regulate their own learning are more effective learners. Yet teachers may not know how to help their students learn to take charge of their own learning process.

Formative assessment is an instructional approach that seeks to develop the kind of ownership and self-regulation that promotes the development of successful learning (Wiliam, 2011). Classrooms that engage in formative assessment practices are ones in which teachers are explicit about expectations for learning and both teachers and students monitor students' work in terms of progress toward those expectations.

9-Conclusion

Implementing effective formative assessment is not a simple matter. It requires sustained attention to teacher's professional development and the impact on student's achievement appears to be significant and reasonably rapid. Students learned significantly and preferred more the Web Based system of doing homework than the traditional way of using only pen and paper in the math. Modeling with functions course. Moreover, in the absence of face to face teaching, this is the best way to let students learn, practice and prepare for the test, as the feedback that they obtain benefits them and give them the right guidance in the absence of the teacher. For the future, we would like to continue using these and some other web based system too, to do math problems in our other math course and for a longer period of time. We hope to get a more accurate result when we do some type of comparison of different types of web based formative assessment systems, in the sense, which one is more suitable for our courses and students.

We are optimistic that online resource will be a powerful tool for diagnosing student thinking, is informative for teachers and thus an important component of the assessment for learning process.

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