AUTHENTIC ASSESSMENT OF STUDENT LEARNING MATHEMATICS WITH TECHNOLOGY

Ida Karnasih
Pascasarjana UNIMED, Medan
ikarnasih2001@yahoo.com

Abstract

The rapid progress of Information Communication and Technology in the 21st Century has influenced the change of the curriculum and its instruction. The government of Indonesia has imposed New Curriculum 2013 for all levels and all subject matters. Among the changes include: the contents, pedagogy and assessment. Moreover, in this new curriculum teachers are recommended to utilize ICT and media in teaching and learning all subjects for primary and secondary level. With the integration of technology, the challenge now is to prepare mathematics teachers know how and when to use technology effectively and to teach an integrated knowledge structure of teaching their specific subject matter and the knowledge of teaching and learning using technology, or Technological Pedagogical Content Knowledge (TPCK). This article describes the characteristics of authentic learning environments, principles of authentic learning, authentic teaching/pedagogy, authentic assessment using technology and TPCK. Example of the implementation is given in using dynamic mathematics software in secondary mathematics.

Keywords: *Authentic Pedagogy/Learning/Assessment, Using Technology, TPCK, Mathematics*

Introduction

In the 21st century, the rapid change of information and communication technology has changed curriculum and instruction in some countries. Indonesian government has changed Curriculum 2004 into New Curriculum 2013. The purpose is to improve the effectiveness of teaching learning quality with the increase and balance of soft skills and hard skills that include aspects of attitudes, skills and knowledge competency. The emphasis of the change focused on the graduate competency standard, the process, the content and the assessment standard. The assessment standard is shifted from assessment through test (product based) into *authentic assessment* (to measure all competencies attitude, skills and knowledge based on the process and product in competency-based assessment (Kemendikbud, 2012). The assessment now is based on the process, the output and the students' ability to do self-evaluation. Authentic assessment requires students to construct unique responses and focuses student activity on complex higher order thinking skills. So, it provides many benefits for promoting deeper, more engaged learning. It responses the demand of external stakeholders for universities to offer more relevant experiences that enhance graduate employability

including the development of authentic graduate capabilities. It also helps students rehearse for the complex ambiguities and unpredictable challenges and roles of working and professional life. (Mueller, 2008)

As the consequent of the technology development, the New Curriculum 2013 has recommended to integrate ICT to become media in teaching and learning of all subjects at secondary school level (Kemendikbud, 2012). With the change of teaching and learning process into "scientific approach" has impact on how the assessment must be done. The challenge now is how to prepare teachers with authentic assessment and to implement it on student learning using technology.

Based on the aforementioned background above, the main focus of writing this article is to briefly explain about the concept and characteristic of *authentic assessment* and its implementation in learning use technology in the mathematics classroom. The discussion is connected to the 21st century teaching, learning and assessment and preparing teachers to teach with technology. It also gives example of the implementation of authentic assessment in learning mathematics using technology, specifically dynamic software Autograph.

Authentic Learning/Teaching/Assessment

Authentic Learning

Revington (writes authentic learning is real life learning. It is a style of learning that encourages students to create a tangible, useful product to be shared with their world. Authentic learning engages all the senses allowing students to create a meaningful, useful, shared outcome. They are real life tasks, or simulated tasks that provide the learner with opportunities to connect directly with the real world. In an authentic learning model the emphasis is mainly on the quality of process and innovation. It's about developing a set of culminating skills sets, within a realistic timeline, using self-motivated inquiry methods to create a useful product to be shared with a specific audience.

a. The Characteristics of Authentic Learning Environments

Rule (2006) writes that authentic learning is a relatively new term that describes learning through applying knowledge in real-life contexts and situations. The term authentic learning is broad and has not been applied to a specific instructional model. He explains the four themes supporting authentic learning experience are:

1. An activity that *involves real-world problems* and that mimics the work of professionals; the activity involves presentation of findings to audiences beyond the classroom.

   One component of authentic learning is that it targets a real problem and that students' engagement holds the possibility of having an impact outside the classroom.
2. *Use of open-ended inquiry, thinking skills and meta-cognition.*

   For authentic learning, students must exercise higher levels of thinking, according to this. For example, learning in mathematics should occur through discovery, inquiry and induction. Instead of math problems that require that students merely apply a known procedure, authentic mathematical tasks require solvers to use different representations in their solutions and to work with realistic and complex mathematical data.
3. Students *engage in discourse and social learning in a community* of learners.

   A community of learners can be a group of learners working together to unravel a problem or refer to the community setting in which the project is based.
4. Students direct their own *learning in project work*.

   Instruction can be personalized by allowing the learner to choose from the rich variety of pathways.

To implement this kind of model in our classroom is to consider it as a kind of framework for planning, whether at the unit, lesson, or activity level. The big idea of all learning then may start with knowing, which leads to valuing, which informs action in relevant and authentic communities. The teacher is the critical ingredient in the whole process of authentic learning, teaching, and assessment.

Rule (2006) writes the successful "authentic teacher" must:

- know how to assess students' strengths and weaknesses and design lessons accordingly.
- know how to guide students to build upon their prior knowledge in a reasonably organized fashion by asking rich questions and providing rich resources for students to utilize in their acquisition of knowledge.
- be the nurturer of the process as students view new information and assimilate their understanding.
- be creative about how student learning experiences can be broadened through sharing with the world outside the school walls.

b. Authentic Learning Supported by Technology

Classroom mathematics teachers have started thinking on how to use technology in their class, in order to engage students in meaningful and immersive learning environments, and also to enable students to use and experience with technology as a powerful cognitive tools. However, what often happens now is that the teacher is the only one to use the technology, usually in the form of exposition of content, such as in PowerPoint presentations or alternatively, the focus sometimes rests solely on the technology itself, rather than on the knowledge, content and processes of the subject area. However, as noted by Churchill (2005) 'technology amplifies our intellectual and physical capacity' (p. 347), and in this context, technology can play an integral role in supporting higher order learning.

Jonassen (2000) has argued that computer technologies, when used as *cognitive tools* or *mindtools*, represent a departure from traditional thinking about technologies, and also technologies can be used by students as 'intellectual partners', and as tools to analyze and interpret their understanding. Moreover, Jonassen (1994) contended: 'Students cannot use [cognitive] tools without thinking deeply about the content that they are learning, and if they choose to use these tools to help them learn, the tools will facilitate the learning process'.

Teachers implement curriculum plans, that include methods and strategies for applying technology to maximize student learning. As facilitators, teachers:

1. facilitate technology-enhanced experiences that address content standards and student technology standards;
2. use technology to support learner-centered strategies that address the diverse needs of students;
3. apply technology to develop students' higher order skills and creativity;
4. manage student learning activities in a technology-enhanced environment.

Authentic Teaching/Pedagogy

Pedagogy means the profession, science, or theory of teaching. How we teach must reflect how our students learn. It must also reflect the world our students will move into. This is a world which is rapidly changing, connected, adapting and evolving. Our style and approach to teaching must emphasize the learning in the 21st century. The key features of 21st Century Pedagogy are: (1) Building technological, information and media fluencies, (2) Developing thinking skills, (3) Making use of project based learning, (4) Using problem solving as a teaching tool, (5) Using 21st Century Assessments with timely, appropriate and detailed feedback and reflection, (6) Using collaborative learning by enabling and

empowering technologies, and (7) Fostering contextual learning bridging the disciplines and curriculum areas.

Authentic Pedagogy was first defined as instruction and assessment which promoted authentic student achievement. It is often involving long-term projects, usually done in groups, about difficult issues that require some complex written or oral final presentation. Authentic teaching occurs when the teacher utilizes information about how students learn and designs learning experiences or tasks based upon this knowledge. Curriculum reformation in mathematics education in Indonesia since 2004/2006 has been focused in student centered rather than teacher-centered, problem solving approach, and using context and collaborative in teaching learning. Curriculum 2013 has been advocating a shift to use "scientific approach" in which students are actively engaged in the discovery or "construction" of their own knowledge. Students should not only learn basic skills, but incorporate those skills into tasks requiring complex thinking and in-depth knowledge which is then used to solve problems and create actual products. With scientific approach, disciplined inquiry occurs when students hypothesize by stating questions and determining resources necessary for task completion. Beyond formulating ideas, students explore and evaluate information, then synthesize to create examples, which illustrate their understanding of the problem. With this approach, both teachers and students have responsibility for what occurs. Students know what they want to learn, have flexible time parameters, and are responsible for staying on task. Teachers use multiple teaching strategies and maintain an environment of ongoing questions and analysis as they learn with their students.

Authentic Assessment

a. What is Authentic Assessment?

Authentic assessment is a form of assessment that is as close to student's reality as possible. It must also have a practical performance criterion, which measures what the tasks set out to do. Mueller and Stiggins defined authentic assessment as follows:

> *" A form of assessment in which students are asked to perform real-world tasks that demonstrate meaningful application of essential knowledge and skills" (Mueller, 2007)*
>
> *"Performance assessments call upon the examinee to demonstrate specific skills and competencies, that is, to apply the skills and knowledge they have mastered." (Stiggins, 1987, p. 34).*

The aim of authentic assessment is to assess many different kinds of literacy abilities in contexts that closely resemble actual situations in which those abilities are used. Both the

material and the assessment tasks look as natural as possible. Furthermore, authentic assessment values the thinking behind work, the process, as much as the finished product (Pearson & Valencia, 1987; Wiggins, 1989; Wolf, 1989).

b. Why Use Authentic Assessment?

Mueller (2008) writes 4 reasons why use authentic assessment :

1. *Authentic Assessments are Direct Measures*

   When students graduate, we want them to be able to *use* the acquired knowledge and skills in the real world. So, our assessments have to also tell us if students can apply what they have learned in authentic situations. Authentic assessments will provide the most direct evidence of the students' acquire knowledge.

2. *Authentic Assessments Capture Constructive Nature of Learning*

   Research on learning have found that students need to construct their own meaning of the world, using information they have gathered and were taught and their own experiences with the world. Thus, assessments must also be asked to demonstrate that students have accurately constructed meaning about what they have been taught.

3. *Authentic Assessments Integrate Teaching, Learning and Assessment*

   Authentic assessment encourages the integration of teaching, learning and assessing In the authentic assessment model, the same authentic task used to measure the students' ability to apply the knowledge or skills is used as a vehicle for student learning.

4. *Authentic Assessments Provide Multiple Paths to Demonstration*

   Authentic tasks tend to give the students more freedom in how they will demonstrate what they have learned. By carefully identifying the criteria of good performance on the authentic task ahead of time, the teacher can still make comparable judgments of student performance even though student performance might be expressed quite differently from student to student

In assessing students' mathematical performance through authentic contexts, teacher must use examples considered to be meaningful for the students. Authentic Assessment goes beyond simple recall of information to complex displays of student ability to communicate, process, apply, and construct knowledge. Examples of authentic assessments include performances which require students to make analogies, explain, exemplify, and generalize information. They also include exhibitions of student products that convey high levels of competence. True authentic assessment must include student self-evaluation, using teacher-

prepared rubrics, or some other tool, to guide the student's assessment. Authentic assessment must provide the student with information about how well they are learning and what areas need improvement.

c. How to Create Authentic Assessments?

As has been mentioned before, in authentic assessment students are asked to perform real-world tasks that demonstrate meaningful application of essential knowledge and skills. To create authentic assessment, Mueller (2008) writes four steps: (1) Identify the Standards (Basic Competency), (2) Select an Authentic Task; (3) Identify the Criteria for the Task ; (4) Create the Rubric

For each criterion, identify two or more levels of performance along which students can perform which will sufficiently discriminate among student performance for that criterion. The combination of the criteria and the levels of performance for each criterion will be your **rubric** for that task (assessment).

The modes of authentic assessment for mathematics could be of the form:

- **Problem-based learning (PBL)** uses real world problems and tasks in which a team of students,
  over an extended period of time, evaluate what they know and what they need to learn in order
  to gain the necessary capacities to generate a response.
- **Scenarios** can require students to notice what is important, explain it using theoretical concepts
  of the course, and plan and theoretically justify an intervention;
- **Portfolios** require that students understand and internalize the learning outcomes of a unit of study and then plan their own set of activities that will generate validated evidence of their performance capability and skill mastery.
- **Writing a journal article** or short story for publication. This can be extended to requiring students to form editorial panels to review the work produced and undertake the full publishing
  responsibilities.

- **Constructing a website** to develop a public education resource and educate a community group about a contemporary issue that the students have identified, studied and researched.(Mueller, 2008)

Preparing Teachers to Teach and Assess with Technology

The challenge for teacher preparation programs in facing the new curriculum 2013 is to preparing teachers to teach an integrated knowledge structure of teaching mathematics as a subject matter, that is the intersection of knowledge of the subject matter with knowledge of teaching and learning, or Pedagogical Content Knowledge (PCK) as characterized by Shulman (1986). But, for technology to become an integral component or tool for learning, mathematics teachers must also develop an overarching conception of their subject matter with respect to technology and to teach with technology or a technology PCK (Technological Pedagogical Content Knowledge). A variety of additional approaches for preparing teachers to teach with technology to move toward the other end of the continuum by: (1) integrating technology in all courses in the teacher preparation program in order to be more supportive of the development of a technology-enhanced PCK and content specific applications and (2) requiring teachers to teach with technology in their classroom.

TPCK requires a consideration of multiple domains of knowledge. Teachers need a well-developed knowledge base in their subject, the improvement of knowledge of the teaching and learning and they learn how to integrate learning and teaching both the subject matter and technology. Teachers implement curriculum plans that include methods and strategies for applying technology to maximize student learning. Teachers : (1) facilitate technology-enhanced experiences that address content standards and student technology standards; (2) use technology to support learner-centered strategies that address the diverse needs of students; (3) apply technology to develop students' higher order skills and creativity; (4) manage student learning activities in a technology-enhanced environment.

Ways to Assess Student Learning Using Technology

We suggest four ways of assessing students learning using technology: (1) analysis of worksheets, (2) observation of students' activities during learning processes, and (3) analysis of saved files and printed-out Using technology, (4) Analysis of project presentation.

1 Analysis of worksheets

By analyzing students' worksheets, we can see students' understanding of concepts or solving problems we give in the worksheets. We can check what student can and cannot do in the worksheets. We also can give feedback to the students.

2. Observation of student's activities during learning processes

Teacher observes students' activities especially while working and the discussing with other students. We can recognize their activities either in a prepared checklist or as an overall opinion. For example: Showing interests in discussion, showing skillfulness in using the technology, following the instruction carefully, communicating with fellow students, Justifying their opinions, summarizing the content of discussing and applying it.

3. Analysis of saved files

By analyzing the process of students' works using the saved files we can get information about students' understanding of concepts and solving problems. We also can ask students to write down the steps they are doing while constructing the graph.

4. Analysis of project presentation

Teacher observes and analyzes students' presentation of the project done either by group or individual. By analyzing the presentation e can see students' creativity in doing the project using technology.

Autograph: Dynamic Mathematics Software

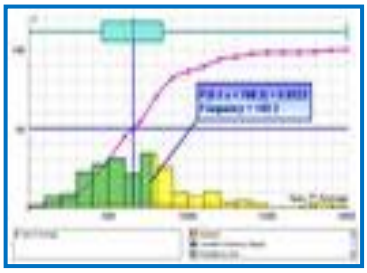
There is now plenty of evidence to show that teaching secondary and college level mathematics with dynamic software is more effective, more efficient, and above all more enjoyable (for both teacher and student). Dynamic software is often employed as a fertile learning environment in which students can be actively engaged in constructing and exploring mathematical ideas (Cuoco & Goldenberg, 1996).

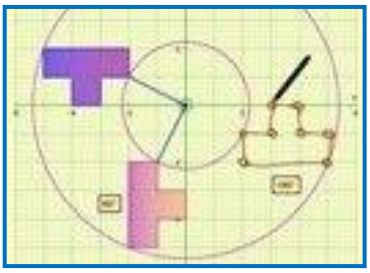
Autograph is a dynamic and very versatile software for teaching and learning mathematics developed by Douglas Butler. In 2000 Douglas Butler founded the innovative iCT Training Centre, based at Oundle School, which is now creating new resources for the educational use of computers in mathematics (Autograph), and running the **TSM** (*Technology in Secondary and College Mathematics*) teacher training events in the UK and many countries overseas.

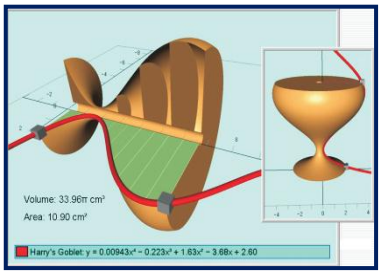
Autograph is designed to help students and teachers visualize mathematics at secondary/college level, using dynamically linked objects'. It is able to sketch curves (both

implicitly and explicitly defined) solve simultaneous equations, plot derivatives, etc. Autograph is a new dynamic PC program operating in 3 modes: 1D for Statistics & Probability, 2D for Graphing, Coordinates, Transformations and Bivariates Data, and 3D for Graphing, Coordinates and Transformation Geometry.

Autograph has two levels of operation, 'Standard' and 'Advanced'. The 'Standard' level has a greatly simplified interface and a reduced set of options for the less experienced user. Standard Level has been designed for ages 11-16. The interface is simpler (larger icons), and we cannot move out of degrees into radians.







ID – 1 Dimension **2D – 2 Dimension** **3D – 3 Dimension**

In Advance Level the interface embraces many more options for the discerning user, including calculus, probability distributions, and equations in 3D. At the 'Advanced' level, more challenging problem and investigations can be explored.

Autograph is the ideal solution for the instructor looking to bring mathematics to life. Whether through true-to form animations or through student-driven exploration, its powerful features and point-and-click technology will engage all levels of students. In real-time, users can observe how functions, graphs, equations, and calculations. It also enables users to change and animate graphs, shapes, and vectors already plotted to encourage understanding of concepts. In mathematics class the use of mathematical software enable students to visualize and further understand mathematical phenomenon in real life.

Teaching by integrating Autograph in schools might increase the effectiveness and the quality of teaching. As mathematics class needs lots of interaction, reasoning, observation the above view clearly indicates that interactive software like Autograph can be useful in teaching and learning mathematics effectively. Use of Autograph help teachers in making students attentive towards the interactive whiteboard and acts as a medium of interaction among students or between teacher and the students with rapid responses. The use of Autograph allows learners to acquire skills and knowledge in using the computers whilst concurrently explore the potentials of the software.

Example of Authentic Assessment in Ict Course

This paragraphs show example of using authentic assessment in ICT course in mathematics education of college students. The title of the course is "ICT Integration in Teaching and Learning Mathematics". The activities was conducted out of/in classroom. All students have laptop and internet connection. The activity was predicting graph of function using Dynamic software Autograph in teaching secondary mathematics. The lecturer used strategy Think-Talk-Write with discovery learning method. The scenario of the class activities described below.

Grade Level : College level (Undergraduate)

Course : Algebra

Procedure :

- Students have been trained to use Autograph in learning graph of various functions as quadratic or trigonometric function.
- The teacher gives students authentic tasks to do in pair using dynamic software Autograph. The purpose is to enrich students with experience by investigating and through real world problems dealing with graph of functions.

Activity : Students and teacher work outside of the class to create a parabolic curve:

1. Group1 squirting water from a hose with different angles.
2. Group 2 playing jumping rope with different distance among the rope holders.

One person on each group doing the activity and other people taking photos.

Student tasks (in group) :

a. To observe the photo on the laptop and predict the parabolic function formed by those squirting water (without Autograph). Different group observes different photo of different squirting angles or different distance of rope holders. (*The Lecturer observing students in each group*)

b. Then, they predict the function (the math model). (*The lecturer asking each group to write on the board the predicted function/equation- cannot be changed*)

c. Use Autograph to check their prediction as follows:

- Copy the picture to Autograph
- Enter the predicted equation into Autograph
- Check whether the equation fit to the picture in the Autograph (*The lecturer checking which group having the best prediction*)

- Students discuss with their friends to make a change of the function by observing the different between the picture and the predicted function
- Suppose students predict the function of the form: $ax^2 + bx + c = y$

Student discuss in the group and can make change the value of a, or b, or c to a bigger or smaller number until they get the graph exactly fit to the picture (*The lecturer ask the group to record how many changes they make until they get the correct answer and which group did the best*).

Conclusion

The New Curriculum 2013 of Indonesia in recent years encourages teachers to look at not only the knowledge, but also attitudes and skills. It emphasizes on new goals, approach on teaching , learning and assessment strategies. The assessment standard is shifted from assessment through test (product-based) into *authentic assessment* (to measure all competencies attitude, skills and knowledge based) on the process and product in competency-based assessment. The most important reason for shifting assessment practices is to make sure our curriculum goals, instructional methods, and assessment practices align. To be effective as part of educational process, assessment should be as an integral part of learning and teaching. The success of the implementation depends on the teacher's competency in this new assessment.

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