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Authentic Assessment of Student Online Learning in a Mathematical Classroom during the Coronavirus (COVID-19) Pandemic

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Abstract

This research developed an authentic assessment of student online learning in a mathematical classroom during the coronavirus (COVID-19) pandemic based on the conceptual framework of Tall (2020a). The target group comprised five students from Rajamangala University of Technology Suvarnabhumi, Suphanburi Center and seven students from Rajamangala University of Technology Phra Nakhon who enrolled in the Calculus 2 course. Data were collected from an authentic assessment of student online learning in a mathematical classroom using Google meet, structured interviews, assigned tasks and field notes. Findings indicated that students' thinking progressed from an embodied world into a symbolized world and then into a formalized world through online teaching technology by applying mathematical concepts to promote increased learning output.

Keywords: Authentic assessment, Online learning, Mathematical classroom, COVID-19

Introduction

An authentic assessment of student online learning in a mathematical classroom was conducted during the coronavirus (COVID-19) pandemic as a viable option during times of social distancing. Measurement and evaluation of learning methods are important and relate to learning objectives. Learning outcome quality measurement and assessment models to measure behavior, work processes and performance collect data in numerical form (Poikela, 2004; Mueller, 2006) to create an effective measurement and assessment of learning (Office of the Royal Society, 2012). Problem posing activities are useful in the mathematical

development of students' understanding. Problem posing activities can have a positive impact on creative students, attitudes to mathematics and critical thinking skills (Nedaei, et al., 2022).

An authentic assessment evaluates students' learning based on the behaviors they exhibit during work activities in the classroom, as reflected by project work, portfolio presentations, observations, interviews and self-assessment (Thumthong, 2013). This performance assessment mirrors real-life situations (Wiggins, 1993; Nitko & Brookhart, 2007) and reflects their knowledge and skill levels (Widyastuti et al., 2021). Exploring assessment across

cultures teachers' approaches to assessment in the U.S., China, and Canada. professional development for teachers related to assessment should focus on the cultural dimensions of assessment in order to prepare teachers to understand and support students' acculturation (Christopher, D., Rickey, N. & Andrew Coombs, A., 2021). An authentic assessment model encourages students to learn on their own by developing process skills according to individual potential.

Online learning activities should focus on 1) Face-to-face meetings with online learners, 2) Emphasis on online self-learning activities through discussions and group interactions, 3) Checking work assignments, 4) Online tests and 5) Feedback (Titan et al., 2017). Online learning systems in mathematical classrooms should emphasize the enthusiasm and liveliness of the teacher to encourage students to participate and comment on their activities. Feedback from teachers is very important in online learning scenarios.

The COVID-19 pandemic necessitated a change in educational learning management styles with the adoption of digital technology. In Thailand, educational institutions were closed during the pandemic and replaced by online teaching and learning. This transition to technological teaching and learning heralded a novel method of global education (Nadeak, 2020). The COVID-19 crisis precipitated new learning styles and online teaching as an alternative approach to problem-solving. All parties involved must be aware and prepared to adapt to this new way of life.

Online learning differs from conventional learning, where teachers and students meet in a class to perform activities and interact, allowing the teachers to competently manage the instruction. In online classes, teachers and students are in different places; they communicate through sounds, pictures and animations. Under these circumstances, students can easily lose interest and become bored, and close monitoring and control may be difficult (Thongserm, 2020). Therefore, teachers must firmly manage online classes so that students can acquire knowledge and skills by cooperating in activities through effective learning management.

Authentic assessment is used to evaluate normal classroom activities and guide the improvement of teaching and learning. Students learn how to be independent, using flexible thinking methods consistent with urban mathematics education research on the role of mathematics compliance at the school level (Martin, Gholson, & Leonard, 2010) and the possibility of changing mathematics education for greater equality (Gutstein et al., 2010; Martin & Larnell, 2013). Three key analytical units of mathematics teaching include teachers, learners and subject content (Cohen, Raudenbush, & Ball, 2003; NCTM, 1991; Stein, Smith, Henningsen, & Silver, 2009). Mathematics teaching combines cognitivism/behaviorism, constructivism and sociocultural perspectives, as 21st-century learning management (Stinson & Bullock, 2012). Strategies for applying learning theory in teaching and learning management must consider the learning objectives and differences between students and the study context.

This paper presents an authentic assessment of online learning abilities in a mathematical classroom for problem-solving during the COVID-19 pandemic in both concrete and abstract manners following the concept of Tall (2020a).

Literature review

Authentic assessment

An authentic assessment is a learning process that requires skills and knowledge in problem-solving and creating tasks that can be applied in practical extracurricular situations. Learning activities consist of academic investigations, knowledge building and creating value beyond the class. Identifying what has been learned and the knowledge still required will enable a better understanding and allow students to plan their studies more effectively (Linn & Miller, 2005). Many assessment methods including project work, portfolio presentation, observation, interview and self-assessment can be utilized to complement written tests (Thumthong, 2013). These enable learners to reach their full potential and develop existing abilities to higher levels (Herman, Aschbacher, & Winters, 1992).

This paper presents authentic learning as a dimension of problem-solving, covering concrete to abstract aspects following the concept of Tall (2020a), with emphasis on basic physical objects to create ways of thinking called conceptual embodiment and operational symbolism. Both these concepts have been developed using complex mathematical models based on their coherence, from observation to theoretical mathematics, as a property that can be inferred from the coherence of the change from theoretical mathematics to formal mathematics in the 20th century following axiomatic formalism adapted to reality-based learning. Learners confront real situations in their daily life and collaborate to learn and search for knowledge as well as problem-solving methods that require various skills and complex thinking. Assessment activities should be challenging to encourage the development of cognitive skills.

Online learning

Online technology in the digital era has moved the educational goalposts and changed the concepts of learning methods to deliver effective online teaching. The components of online teaching include teachers, students, content, materials and resources, learning management processes, communication systems, information technology networks, measurement and evaluation. Various teaching styles allow teachers and students to interact online to overcome social distancing constraints using high-speed Internet networks (Matthews & Schrum, 2003), online teaching technology (Breslow et al., 2013) and educational applications (Chen, Sivo, Seilhamer, Sugar, & Mao, 2013).

The 21st-century teaching paradigm of online learning, introduced as a result of the 2019 coronavirus pandemic, has necessitated changes in lesson design, classroom management, media use, measurement and evaluation. Online teaching must be embraced and accepted by all parties involved as a new way forward for Thai education. Therefore, knowledge of online learning management skills is important for both teachers and students.

This article assesses the impact of digital technology-based online learning management. Teachers must study the key elements of online learning and adapt their teaching-learning styles using applications such as Google Classroom, Hangouts Meet, Google docs and Google drive.

The mathematical classroom

A mathematical classroom provides students with a thinking space linking the real world to the mathematical world. Becker & Shimada (1997) suggested that mathematical learning was a link between the real world and the mathematical world through various channels, as shown in Figure 1.

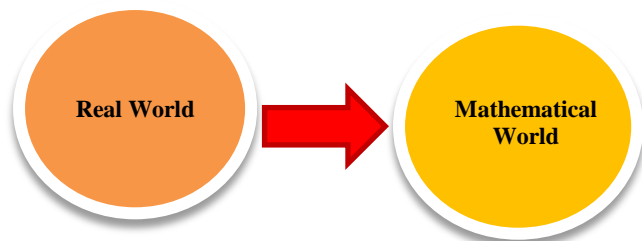


Figure 1. Becker & Shimada's conceptual mathematical thinking model (1997)

From the review of related documents and research, the theoretical framework was analyzed as follows:

1. Mathematical thinking from the concrete level (Embodiment world) is a mathematical concept that applies thinking from mediums, devices or physical objects.
2. Mathematical thinking from a semi-integrated level (Symbolism world) is a mathematical concept that does not rely on thinking with media, devices or physical objects but thinking that uses a mathematical notation method.
3. Mathematical thinking from an abstract level (Formalism) is a mathematical concept that uses axioms, formulas, definitions or theorems in mathematical thinking (Tall, 2020a).

Objective

To authentically assess the online learning processes of students in a mathematical classroom during the COVID-19 pandemic.

Methodology

This qualitative research focused on the behavioral thinking of the target group using classroom observation (Steffe & Thompson & Glasersfeld, 2000). The subjects were five students from Rajamangala University of Technology Suvarnabhumi, Suphanburi Center and seven students from Rajamangala University of Technology Phra Nakhon, Bangkok who enrolled in the Calculus 2 course.

Research tools

1. The assessment of student online learning management in a mathematical classroom was conducted using Google Classroom, Hangouts Meet, Google docs and Google drive combined with 2. Structured interviews, 3. Student tasks and 4. Field notes.

Research processes

1. Create collaborative learning activities following polar coordinate systems according to management plans. Learning activities included objectives, problem-solving tools and supporting media.
2. Create an authentic assessment of online student learning in a mathematical classroom with input from three learning assessment experts, two mathematics education experts and two educational technology experts. The concept was tested to discover how a group of learners adapted to an online mathematical classroom.
3. Develop a teaching-learning management model using the following applications:

- 3.1. Google Classroom is a virtual environment for teaching and learning. The service also includes Docs (Google docs), Drive (Google drive) and electronic mail (Gmail) so that teachers can manage classroom activities.
- 3.2. Hangouts Meet is used to organize both one-on-one and group teaching activities as a real-time activity in the form of video conferences for students to discuss solving math problems. Theoretical lessons can be saved as videos on Google drive. This application can interface with Google Classroom, recording mathematical teaching activities, discussions and opinions so that students can learn or review the contents at any time.
- 3.3. Google docs allows document sharing with other students and teachers. Students can easily track the progress of their work.
- 3.4. Google drive is used to store online data, with access to work files anytime, anywhere.

All students can access the documents without having to download to their own computer, allowing collaboration on the same document at the same time.

4. Develop an authentic assessment of student online learning in a mathematical classroom. The other two teachers from the same course of the researcher examined student learning efficiency in mathematics classes by online learning management.

Data collection

1. Field notes were compiled to record student online learning outcomes in a mathematical classroom. The students were instructed to turn on the camera and the microphone while talking together to solve problems.
2. Video recordings of teaching events and field notes were used to assess student learning outcomes in a mathematical classroom.
3. Student tasks were assessed to determine online learning outcomes in a mathematical classroom.
4. Interviews were conducted with the target group to determine problem-solving techniques.

Data analysis

1. Field notes and video recordings were analyzed and reviewed using data triangulation.
2. Target group interviews were conducted to analyze the online learning techniques of students in a mathematical classroom.
3. The students' learning techniques in a mathematical classroom were verified to demonstrate the development of their thinking processes through group discussions, and then draw conclusions.

Results

An authentic assessment of student online learning in a mathematical classroom was conducted during the COVID-19 pandemic. Mathematical lessons and media were prepared following the learning management plans in the supporting documents along with supporting technologies. The role of teachers, which supported learner thinking based on their efficiency in accordance with the conceptual framework of David Tall (2020a), revealed that the authentic assessment was best conducted through problem-solving from real situations of mathematical concepts / principles. Learner thinking starts from

objectivity (embodiment world), i.e., mathematical concepts that use media, equipment/devices or physical objects (considered by the graphs in polar coordinates), and proceeds through mathematical thinking by combining objectivity and subjectivity (Symbolism). Mathematical concepts do not rely on thinking that uses media, equipment/devices or physical objects but rather symbolic methods that finally lead to subjective thinking (Formalism) using axioms, formulas, definitions or theorems that can be divided into three forms as follows:

1. Authentic assessment by problem-solving that uses previous methods or knowledge as a tool relies on graphing, formulas and forecasting answers. At this level of thinking, learners connect their thinking to media and physical objects.
2. Authentic assessment by problem-solving that uses calculation and substitution to find plot lengths in polar coordinate systems based on basic calculation and solving equations as the tools for answers. At this level of thinking, learners connect numerical thinking and symbolic thinking.

Authentic assessment by problem-solving that uses mathematical programs to verify/examine mathematical concepts for further generalization. At this level of thinking, learners extend their thinking of subjective mathematical principles as definitions, rules, formulas, theories, symbols and mathematical axioms, as shown in Figure 2.

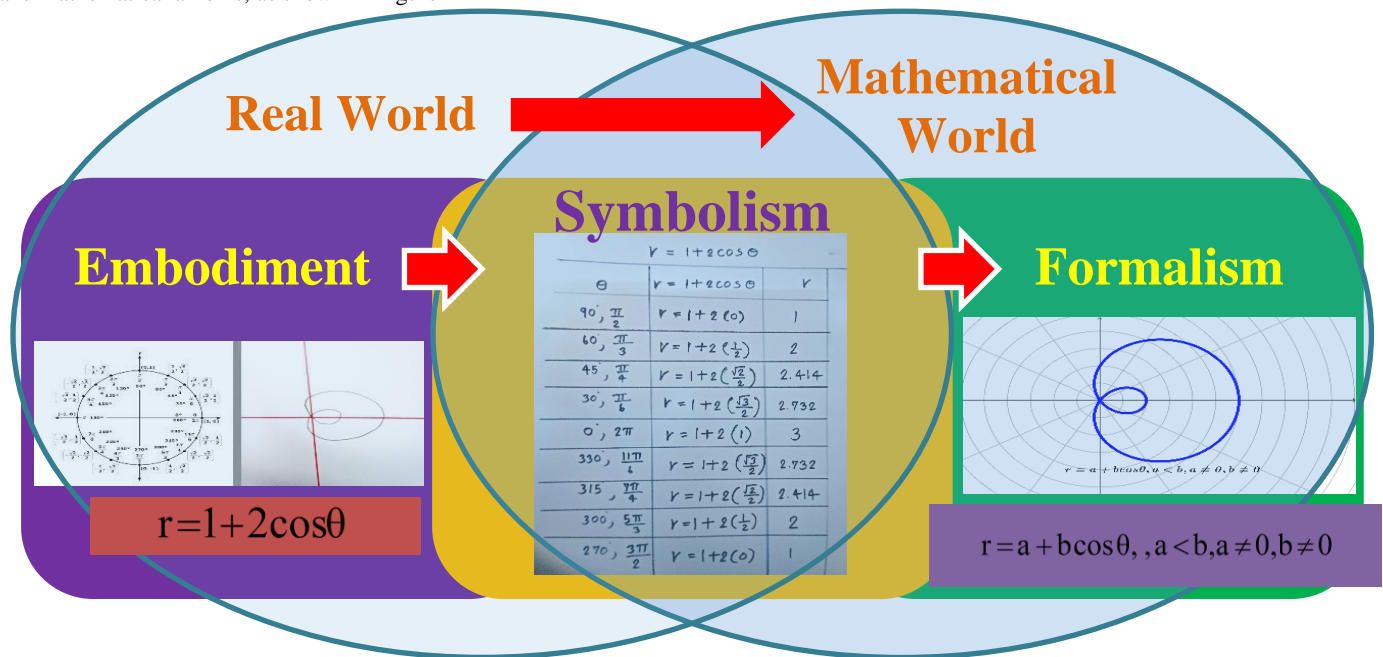


Figure 2 Authentic assessment of the student's problem-solving model

1. The learner reads the instruction from the teacher to draw a graph of polar coordinates.
2. The learner searches for available methods used in the previous class, i.e., angle and radius length measurement, writing coordinates in polar coordinate systems (r, θ) , symmetry of the graphs in the polar coordinate system and turning the angle from degrees into radians. They then use these concepts to shade the

angles of graphs in the range 0 to $\frac{\pi}{2}$, and $\frac{3\pi}{2}$ to 2π .

3. The learner sketches/outlines a graph.
4. The learner calculates by representing the angles at

$0^\circ, 30^\circ, 45^\circ, 60^\circ, 90^\circ$ and

$270^\circ, 300^\circ, 315^\circ, 330^\circ, 360^\circ$ in $r = 1 + 2\cos\theta$.

5. The teacher presents the programs "GeoGebra" and "Desmos" for the learners to understand graphs in

different equations of polar coordinates, e.g., $r = 1 + 3\cos\theta, r = 2 + 3\cos\theta, r = 2 + 4\cos\theta$

6. The learner then searches for generalization of $r = a + b\cos\theta, a < b, a \neq 0, b \neq 0$.

Discussion

1. An authentic assessment of student online learning in a mathematical classroom was conducted during the COVID-19 pandemic. Learning management was planned in accordance with the actual assessment methodology, i.e., curriculum analysis, learning management plan development for authentic assessment and measurement as well as assessment tool design. This concept was consistent with Wiggins (1989) who posited that authentic assessment refers to performance assessment using knowledge, reasoning and thinking at a higher level than right or wrong answers. The students learn by performing high-level thinking tasks that are valuable and useful. Teachers must help the students to discover their own needs by themselves.
2. Learning management promotes real-world learning and enhances the students' ability to develop thinking and graphing methods into definitions, rules, formulas, theories, symbols and mathematical axioms consistent with the constructivist theory, which posits that self-

learning is created by the learners themselves. Learning cannot occur by direct instruction under limited time but occurs everywhere using different methods. Individuals can use and improve their knowledge to react to new situations which are different from previous experiences (Baruque et al., 2004).

3. Authentic assessment allows students to review their work, conduct further research and receive feedback to improve the results. Teaching, learning and assessment relate to and affect each other. Individual progress is emphasized rather than compared with other learners. This approach corresponds to Mathematics Reform in Urban Schools that focuses on class-level reform processes (Rousseau Anderson & Tate, 2008; Rousseau Anderson, 2014). To improve teaching and learning, the theories underpinning the creation of reform at the institutional level include (a) consistent support systems for teaching and learning, (b) teacher networks, (c) the role of mathematics coaches in supporting teacher learning, (d) school leadership practices and (e) decentralized leadership practices. The mathematics classroom context in Thailand has an open learning management approach using classroom education innovation. Students in the class focus on solving problems by themselves. Designed mathematics activities use open-ended problems to create situations that support student learning (Inprasitha, 2011). Problem-solving is a core activity in mathematics classes at all levels of global education (NCTM, 2000).

Conclusions

Authentic assessment of learners in mathematical classes was conducted by online learning management during the coronavirus pandemic. Student thinking was developed from the embodiment world into the symbolism world, and then to the formalism world. Instructional media facilitated learners to create mathematical ideas that led to generalization, while teachers promoted mathematical conceptualization. Students explain how to write graphs from graph movements that help reflect mathematical concepts. Understanding mathematics Visual representation encourages students to explain a wider and more diverse range of mathematical concepts. The use of educational technology in teaching and learning helps students learn meaningfully, reducing content and time problems. It also increases teaching and learning efficiency and increases educational effectiveness by meeting learner differences. Students can study according to their abilities, which is a good response to the interests and needs of the individual.

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