FORMATIVE ASSESSMENT USING MOBILE TECHNOLOGY FOR INTELLECTUAL AND EMOTIONAL ENGAGEMENT OF STUDENTS IN LEARNING 'MEASUREMENT SYSTEMS'

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Abstract - The purposes of this study were (1) to measure the correlation between students' formative assessments scores using mobile technology (Kahoot!) and the students' achievement scores, and (2) to assess students' perception on reduction of anxiety in learning through formative assessment using the mobile technology. The participants were 16 first year chemistry students in Chemistry Program at Faculty of Science and Technology, SuanSunandhaRajabhat University. The researchers provided activity sheet to develop students' mathematical concepts in 'Measurement Systems' and created the mobile technology (Kahoot!) for formative assessment in two topics: 'Scientific Notation' and 'Metric Prefixes' to raise the level of students' achievement. The results demonstrated that the effect of formative assessment using mobile technology (Kahoot!) as intellectual engagement contributed positive correlation on students' achievement or learning, $r = .677$ and $p = .004$. In addition, this study points to the effective pedagogy in creating mobile technology worthwhile for reducing mathematics anxiety as emotional engagement in learning mathematics for science students.

Index terms - Formative assessment, Mobile technology (Kahoot!), Engagement in learning mathematics, Anxiety in learning mathematics, Measurement systems

I. INTRODUCTION

First year chemistry students in Chemistry Program at Faculty of Science and Technology, SuanSunandhaRajabhat University are required to take General Chemistry 1 and General Chemistry Laboratory 1. These two courses are known to be two barrier courses to success among many first year chemistry students.

For academic year 2017, there were 16 first year chemistry students of Faculty of Science and Technology, SuanSunandhaRajabhat University, with mixed abilities in high school mathematics before starting semester 1, academic year 2017. On the basis of unprepared students in high school, mathematics must undertake a bridging program and/or remedial teaching program to introduce key mathematical concepts and techniques to solve problems in General Chemistry 1 and General Chemistry Laboratory 1. The difficulties were due to students' inabilities to: (1) state the different measurement systems used in chemistry, (2) describe how prefixes are used in the metric system and identify how the prefixes compare to the base unit, and (3) to identify SI units of mass, distance (length), volume, temperature, and time. It is important to realize that values in scientific measurements allow the students to quantify the accuracy of any types of measurement including the conversion of units of measurement. If a student's balance is not calibrated correctly, the measurement will not represent the true value.

This study was the collaboration of the lecturers from Mathematics Education Program, Chemistry Program, and graduate students studying at International College, SuanSunandhaRajabhat University. The researchers designed the intervention active learning activities for developing the first year chemistry students to understand the importance of units and transfer mathematical concepts for measurement systems used in chemistry context using formative assessment with mobile technology (Kahoot!) for raising level of achievement and decreasing anxiety in learning mathematical concepts. The objectives of this study were the followings:

1) To measure the correlation between students' formative assessments scores using mobile technology (Kahoot!) and the students' achievement scores, and
2) To assess students' reduction of anxiety in learning through formative assessment using the mobile technology.

The research questions were the followings:

1. Is there any relationship between formative assessment using mobile technology (Kahoot!) for intellectual engagement and students' learning?
2. Does Formative assessment using mobile technology (Kahoot!) for emotional engagement help students reduce their anxiety in learning mathematics?

II. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The researchers were interested in 'The Impact of Formative Assessment', which influencing on students' learning. There were two theories applying in this study:

'Teaching and Learning Theory' and 'Formative Assessment Principles'.

TEACHING AND LEARNING THEORIES

Teaching and learning is a process concerning with the development of person's intellectual, emotional, behavioural and social potentials. In educational reform, the teachers apply student-centered approach for leading the students to learn activelyand afford foundation for lifelong learning. The role of teacher will be changed; the teacher is no longer the 'authority' but instead is a guide or facilitator who engages students in 'learning how to learn'[1].

Center for Teaching and Learning, University of Washington [2] referred to research which demonstrated that engaging students in the learning process increases their attention andhelps everyone more successfully, achieve the course's learning objectives.

In classroom, when students are engaged with the lesson being taught, they learn more and retain more. Students who are engaged in work tend to persist more and find joy in completing the work. Also, wisely managed classroom technology is one innovative teaching strategy that engage student. There are innovative apps and websites can help teachers engage students, for examples, Google Docs, YouTube videos, Quizlet, Kahoot!, and the Remind app. In addition, these apps and website can help teachers remind their students about upcoming assignments and homework [3].

FORMATIVE ASSESSMENT PRINCIPLES

Formative assessments are assessment designed to monitor student progress during the learning process. Essentially, formative assessment seeks to present students with learning outcomes, to help them assess their current position in relation to these outcomes, and to equip them with the tools to bridge the gap between their position and learning outcomes [4].

The Organisation for Economic Co-operation and Development [5] states that:

> Formative assessment builds students' "learning to learn" skills by emphasizing the process of teaching and learning, and involving students as partner in that process. It also builds students' skills at peer-assessment and self-assessment, and helps them develop a range of effective learning strategies.

According to Ramsey[6]formative assess- ment is fundamental to good teaching which increases student engagement, allowing students to take ownership of their learning. This author mentions that 'teachers who use technology for formative assessment generally love the ease with which programs such as Plickers or Kahoot! provide immediate feedback on student learning'. Research has accumulated that shows a positive relationship between formative classroom assessment and student motivation and achievement (Brookhart, 2007; Black and Wiliam, 1998; McMillan, 2004, as cited in [7]). Students learn more through formative assessment for four primary reasons[7]:

1. Frequent, ongoing assessment allows both for fine-tuning of instruction and student focus on progress.
2. Immediate assessment helps ensure meaningful feedback
3. Specific, rather than global, assessments allow students to see concretely how they can improve.
4. Formative assessment is consistent with recent constructivist theories of learning and motivation.

MISCONCEPTIONS IN MEASUREMENT SYSTEMS

Many students have common misconceptions in knowledge and procedure of measurement systems.

Students forgot to write the unit which will make the number meaningless and they cannot convert between different systems of measurement by using conversion factors.

For misconceptions, students may multiply when converting to larger units and divide when converting to smaller units; they may not know the prefixes used in metric system or their meanings; they may not be able to choose appropriate units or make reasonable estimate.

In this study, the lecturers of Mathematics Education Program, International College, SuanSunandhaRajaphat University were interested in enhancing graduate student learning through a 'student as researchers' pedagogy. The graduate students worked as researchers analyzing 16 first year chemistry students' misconceptions and focusing on two topics of measurement systems: 'Scientific Notation' and 'Metric Prefixes'. Their teaching strategy was an active learning included mobile technology (Kahoot!) for engagement and learning.

MOBILE TECHNOLOGY (KAHOOT!) AND STUDENT ENGAGEMENT

In education, the concept of student engagement refers to the ways to support students to increase their intellectual, emotional, behavioral, physical, and social behavior in the learning process. The teacher can create learning activities in a course or subject that appeal to student interests or that stimulate their curiosity for intellectual engagement. Teachers may use a variety of strategies to promote positive emotion in students for emotional engagement.

> Emotional engagement involves interest, boredom, happiness, anxiety and other affective states, any of which factors could affect learners involvement with learning or their sustained effort in playing games, such as in the context of playing a game. [8]

In addition, teachers may establish classroom environment to foster students for behavioral engagement, physical engagement, and social engagement.

In this study, the researchers focused on student intellectual and emotional engagement in learning mathematics. Battista [9] suggested that students will

engage in learning mathematics as sense making at the top level of engagement. The researchers designed activity sheets involving mathematical concepts (measurement systems)with sense making for chemistry students. In addition, the researchers created formative assessment with this mobile technology to engage intellectual for achievement and engage emotional behavior for decreasing anxiety in learning mathematical concepts.

Matthes[10] wrote online newspaper on topic about 'Teachers aim for student engagement, participation: New techniques help get all students involved'. Matthes mentioned that,

> "The teachers use different methods to get students more engaged in the topic that they are learning. … One of the resources teachers use is called Kahoot!, which gives a game-like feel to learning. A question will appear on the screen and the students have a certain amount of time to answer it with their devices. Students enjoy playing Kahoot!, because it help them understand the lesson better while having fun."

Several previous studies have demonstrated that the ease of using mobile technology by applying game-based learning approach can increase the internal motivation and learning achievement of students [11]. Potter's research project applied Kahoot! for formative assessment and found that integrating digital formative assessment impacts the learning of students, if used correctly, can help improve student achievement [12].

According to Bolkan[13], "Kahoot! is a free game-based learning platform that allows teachers to send students challenges as homework and allows students to practice anywhere and anytime they like, alone or with other students."

In this study, the researchers developed activity sheets on 'Measurement Systems' related to chemistry contexts and created two topics: 'Scientific Notation' and 'Metric Prefixes' for formative assessment through mobile technology (Kahoot!).

FORMATIVE ASSESSMENT AND ACHIEVEMENT

In classrooms, formative assessments are used to assess student progress and identify learning needs. Teachers prepare formative assessment approaches and techniques to meet diverse students' needs and adapt teaching to raise levels of student achievement and to achieve student learning outcomes. In addition, formative assessment builds students' "learning to learn" skills by [5]:

- -Placing emphasis on the process of teaching and learning, and actively involving students in that process.
- -Building students' skills for peer-and self-assessment.
- -Helping students understand their own learning, and develop appropriate strategies for "learning to

There are a variety of formative assessment approaches [14]: self-assessment, peer assessment, questioning, and feedback. When these are created in an appropriate learning management plan, teacher will have significant, positive impact on students' achievement.

In this study, the researchers applied this mobile technology used in formative assessment and students got feedback to improve their learning. After classroom, the students practiced to use Kahoot! as homework for their own learning before taking the posttest.

III. RESEARCH METHODOLOGY

PARTICIPANTS

The participants in this research were 16 first year chemistry students in Faculty of Science and Technology at SuanSunandhaRajabhat University in Bangkok, Thailand.

RESEARCH INSTRUMENTS

1. Activity sheets for two topics: 'Scientific Notation' and 'Metric Prefixes', which each activity sheet composes of Main Concept, Discussion, and Conclusion
2. Mobile technology (Kahoot!) for engagement and assess learning: formative assessment for 'Scientific Notation' and 'Metric Prefixes'
3. A posttest consisting of 20 questions
4. Students' Perception on Reduction of Mathematics Anxiety Questionnaire consisting of 10 items

RESEARCH PROCEDURE

The procedure of this study was divided into 3 cycles (3 periods), and each cycle consisted of 4 steps: Plan, Act, Observe, and Reflect. First period was about scientific notation and second period was about matric prefixes. In the last period, there was wrapping up the concept of the lessons by using 'question chain' which will start from teacher then continue to next student around the class.

DATA COLLECTION

There were two objectives of this study: (1) to measure the correlation between students' formative assessments scores using mobile technology (Kahoot!) and the students' achievement scores, and (2) to assess students' reduction of anxiety in learning through formative assessment using the mobile technology. The researchers collected two types of data as follows:

1. Quantitative Data: Students' scores from formative assessment via this type of mobile technology and posttest scores
2. Qualitative Data: Students' Perception on Reduction of Mathematics Anxiety Questionnaire

DATA ANALYSIS

Researchers analyzed quantitative data for Objective 1 and qualitative data for Objective 2 as the following details:

Objective 1: The researchers applied descriptive statistics by calculating a correlation coefficient between students'

formative assessments scores using mobile technology (Kahoot!) and the students' achievement scores.

Objective 2: The researchers analyzed students' perception on reduction of mathematics anxiety applying Five Likert-Type Items (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree) by calculating frequencies in percentage and categorized students' performances on reduction of anxiety in mathematics related to chemistry lessons.

IV. RESEARCH FINDINGS

OBJECTIVE 1:

The data were analyzed by using Pearson's correlation coefficient as follows:

$$r = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2}\sqrt{\sum_i (y_i - \bar{y})^2}}$$

Where, x_i are students' scores from formative assessment via mobile technology (Kahoot!)

y_i are students' scores from posttest

$\bar{x}$ is the mean of students' scores from formative assessment via mobile technology (Kahoot!)

$\bar{y}$ is the mean of students' scores from posttest

The results of calculating Pearson's correlation coefficient for Objective 1 were shown in Table 2.

Table 2
The correlation coefficient (r) between formative assessment scores (Mobile technology: Kahoot!) and achievement test (Posttest)

Types of Assessment	N	Mean	SD	r	p
Formative Assessment	16	15.56	3.054	.677	.004
Achievement test	16	13.34	3.687		

Table 2 showed results of mean of students' scores from formative assessment via this mobile technology and mean of students' scores from posttest. The correlation coefficient (r) is .677 and p-value is .004, which indicated that the effect of formative assessment using Kahoot! contributed positive correlation on students' achievement.

OBJECTIVE 2:

The results of data were analyzed by using frequencies in percentage and determined the mode of students' opinion towards the formative assessment via mobile technology impact on their performances on reduction of anxiety in mathematics related to chemistry lessons as shown in Table 3.

Q1: I am not afraid when I have to go to learn my course related to math concepts.

Q2: I am not worried about explaining my answers in topic related to math concepts.

Q3: I do not hesitate to ask questions in lesson related to math concepts.

Q4: I am not worried about being called on in my course related to math concepts.

Q5: I understand math now, and I feel easy to solve complex problems.

Q6: I tend to be interested in my lesson related to math concepts.

Q7: I do not get nervous taking tests related to math like any other kind.

Q8: I know how to study for tests related to math concepts.

Q9: It is clear to me in lesson related to math concepts, and when I go home I can do it by myself.

Q10: I can keep up with the rest of the class to learn lesson related to math concepts.

Table 3
Distribution of Responses and Descriptive Statistics across Items (N=16)

Item	Perception of Reducing Mathematics Anxiety				
	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Q1	62.50	25.00	6.25	6.25	0.00
Q2	37.50	18.75	37.50	6.25	0.00
Q3	18.75	56.25	18.75	6.25	0.00
Q4	31.25	37.5	31.25	0.00	0.00
Q5	37.50	37.5	25.00	0.00	0.00
Q6	56.25	25.00	18.75	0.00	0.00
Q7	18.75	50.00	25.00	6.25	0.00
Q8	37.50	43.75	18.75	0.00	0.00
Q9	50.00	18.75	25.00	6.25	0.00
Q10	62.50	18.75	12.50	6.25	0.00
Average	41.25	33.13	21.88	3.75	0.00

Adapted from Freedman [15]

The distribution of responses was interpreted into 5 performances on reduction of anxiety in mathematics related to chemistry lessons as shown in Table 4.

Table 4
Distribution of Students' performance on reduction of anxiety in mathematics

Scores	Students' Performance (Percent of Times)	Frequency N = 16 (%)
40 – 50	Almost Always (80 – 100 %)	10 62.50
30 – 39	Often (70 %)	4 25.00
20 – 29	Sometimes (50 %)	2 12.50

10 – 19	Occasionally (30 %)	0	0.00
Below 10	Hardly Ever or Rarely (10 %)	0	0.00

Table 4 showed the effect of formative assessment via mobile technology on students' performance (percent of times) in reduction of anxiety in mathematics related to chemistry lesson. The percentage of students indicated that they reduced anxiety in learning mathematics related to chemistry from the most students' performance as follows: 'Almost Always 62.50%', 'Often 25.00%', and 'Sometimes 12.50%', respectively.

DISCUSSION

The results showed that the formative assessment using mobile technology contributed positive relationship to first year chemistry students' achievement. Also, students decreased their anxiety in learning mathematics using formative assessment via this mobile technology. In addition, both results were supported by intellectual and emotional engagement when they employed positive emotional response to learning activities and teacher can use the data from digital formative assessment to guide present class happening, to access a lesson effectiveness, or a student's understanding, and to plan future lesson [14]. Also, the results of this study are consistent with the study by Herreid, Terry, Lemons, Amstrong, Brickman, and Ribbens[16] indicated that emotional engagement revealed significant correlations among emotion, engagement, and learning gains.

LIMITATIONS

In this study, the researchers applied this type of mobile technology to engage the first year chemistry students and to develop their learning actively with activity sheets on topic 'Measurement Systems'. This study was an action research for three periods (cycles). It was done at the beginning of semester 1, academic year 2017.

The limitations of this research study was the constitution of the sample. There were only 16 first year chemistry students not randomly selected from a larger population to participate in the study.Information about this study was collected only three periods for extra class. Therefore, the results might not generalize to other student populations, particularly those in Chemistry Program or Science Program.

RECOMMENDATION

For further study, using digital formative assessment need to continue conducting action research to monitor and engage students with longitudinal study which data is gathered for the same subjects repeatedly over a period of time not limited times and places. There should be measurement of students' anxiety before starting this approach.

CONCLUSION

Based on the results of this study, the researchers conclude that formative assessment using mobile technology (Kahoot!) for intellectual and emotional engagement in learning 'Measurement Systems' on topics 'Scientific Notation' and 'Metric Prefixes' can be used for the first year chemistry students of Faculty of Science and Technology, SuanSunandhaRajabhat University. More interestingly, the presented study provides further support for monitoring and promoting students' progress in learning. Keeping in mind the importance of formative assessment using digital technology, should be conducted as collaborative action research in higher education level between the faculties/departments in college/university for practicing graduate students in doing research in classrooms.

REFERENCES

[1] The Ministry of Education, "The Basic Education Core Curriculum B.E. 2551 (A.D. 2008)," 2008. [Online]. Available: http://www.act.ac.th/document/1741.pdf.

[2] "Engaging students in learning," Center for Teaching and Learning. [Online]. Available: https://www.washington.edu/teaching/teaching-resources/engaging-students-in-learning/. [Accessed: 24-Apr-2018].

[3] J. Davis, "Innovative Teaching Strategies that Improve Student Engagement," AMLE - Association for Middle Level Education, Nov-2017. [Online]. Available: https://www.amle.org/BrowsebyTopic/WhatsNew/WNDet/TabId/270/ArtMID/888/ArticleID/876/Innovative-Teaching-Strategies-that-Improve-Student-Engagement.aspx. [Accessed: 24-Apr-2018].

[4] C. F. Herreid, D. R. Terry, P. Lemons, N. Armstrong, P. Brickman and E. Ribbens, "Emotion, engagement, and case studies", Journal of College Science Teaching, vol. 44, no. 1, pp. 86-95, 2014.

[5] Center for Educational Research and Innovation, Assessment for learning: Formative assessment. Paris: OECD, 2008.

[6] B. Ramsey, "Formative Assessment is Fundamental to Good Teaching," Education First, 11-May-2016. [Online]. Available: https://education-first.com/formative-assessment-is-fundamental-to-good-teaching/. [Accessed: 24-Apr-2018].

[7] K. M. Cauley and J. H. McMillan, "Formative Assessment Techniques to Support Student Motivation and Achievement," The Clearing House, vol. 83, no. 1, pp. 1–6, 2010.

[8] X. Ge and D. Ifenthaler, "Designing Engaging Educational Games and Assessing Engagement in Game-Based Learning," Advances in Game-Based Learning Handbook of Research on Serious Games for Educational Applications, pp. 253-270, 2016.

[9] M. T. Battista,"Engaging students in meaningful mathematics learning: Different perspectives, complementary goals," Journal of Urban Mathematics Education, December 2010, Vol.3, No.2, pp. 34-46, 2010.

[10] K. Matthes, "Teachers aim for student engagement, participation: New techniques help get all students involved," 2017. [Online]. Available: https://canyonchronicle.com/3099/academics/teachers-aim-for-student-engagement-participation/

[11] S. Terrell and P. Rendulic, "Using computer-managed instructional software to increase motivation and

achievement in elementary school children," Journal of Research on Computing in Education, 26(3), pp. 403-414, 1996.
[12] S. E. Potter, "How integrating digital formative assessment impacts the learning of sixth-grade science students. School of Education Student Capstone Theses and Dissertations," 2017. [Online]. Available: http://digitalcommons.hamline.edu/hse_all/4316.
[13] J. Bolkan,"Kahoot unveils app for game-based homework," 2017. [Online].Available:https://thejournal.com/articles/2017/07/05/kahoot-unveils-app-for-game-based-homework.aspx.
[14] H. H. Kinney, "Digital formative assessment with Kahoot and Plickers," 2017. [Online]. Available: http://berwickgtt.blogspot.com/2017/05/digital-formative-assessment-with.html
[15] E. Freedman, "Do You Have Math Anxiety? A Self Test," 1997. [Online]. Available: http://www.pearsoncustom.com/mdc_algebra/math_anxiety_material.pdf.
[16] C.F.Herreid, D.R. Terry, P. Lemons, M. Armstrong, P. Brickman, andE. Ribbens,"Emotion, engagement, and case studies," Journal of College Science Teaching, Vol. 44 No. 1, pp.86-95, 2014.

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