Yang, J. C. et al. (Eds.) (2018). Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education

Development of Gamified Flipped-class Inquiry Learning in Physics Concept of Energy for School Science: An Early Stage

Tanakorn PANOMRERNGSAK[a], Niwat SRISAWASDI[b*]
[a]Science and Technology Education Program, Faculty of Education, Khon Kaen University, Khon Kaen,Thailand
[b]Division of Science, Mathematics, and Technology Education, Faculty of Education, Khon Kaen University, Khon Kaen, Thailand
[*]niwsri@kku.ac.th

Abstract: In over a past decade, Flipped classroom pedagogical method which modifies the learning process is the current trend of education. There are adaptations of flipped classroom integrate with a lot of innovation. Game is an innovation in education, flipped classroom integrates with game elements called gamified flipped classroom. The gamified flipped classroom is based on gamification. Several researchers and educators reported advantages of gamified flipped classroom in promoting motivation to learn science and enhancing scientific conceptions for students. This paper explains a development of gamified flipped classroom in physical science of energy concept for high school students. In this pilot study, there are 195 participants in this development who are high school students in tenth grade in an extra-large public school in Kalasin province at Northeastern of Thailand. The results of the investigation showed that from six concepts of energy; kinetic energy, spring potential energy, gravitational potential energy, energy principle, transformation of energy and conservation of energy. All participants are classified in four categories; scientific conception (SC), incomplete conception (IC), misconception (MC), and no concept (NC). Most of students are in incomplete conception and misconception in physical science concepts related to energy concept. For this reason, the researchers present a conceptual idea for designing an interactive video which uses in gamified flipped classroom addressing the concepts of energy for improving the students' concept of energy, and it might enhance the eliminate of student's misconceptions and increase students' science motivation.

Keywords: flipped classroom, gamified flipped classroom, science education, high school

1. Introduction

There are many studies about the potential strategy to teaching and learning, over the past decades, digital technologies have a great impact on education because of it changes the way to learn (Srisawasdi, 2012). Technology is rapidly evolving and playing a very important role for humans. Therefore, the teaching and learning technique must be in line with the changes in society, the environment, the knowledge of science and technology to develop and enhance the potential of learners to have higher quality of learning. The use of technology for education helps students learn more effectively. And students have a positive attitude towards classroom learning (Schacter J., 1999). The use of mobile phones in teaching is beneficial for learners, giving them the opportunity to learn without setting a time and place to learn (Chaipidech & Srisawasdi, 2016). Moreover, in recent years, game becomes an alternative choice for education. Many educators have developed games for three aims that consist of students are able to learn through playing the game, learning can be supported by game components, and students have been motivated to learn when they are learning by playing game (McNamara, Jackson, & Graesser, 2010). Game incorporates attributes related to the way students learn, they need to explore and reflect on their prior knowledge, solve problems, and transfer knowledge during the game process (Oblinger, 2004).

In addition, the designs of teaching activities or pedagogies are extremely important for learners to learn. The flipped-classroom is a new teaching approach developed by Jonathan and Aaron (Tucker, 2012). Flipped classroom is quickly spread broadly throughout the world; the flipped

classroom teaching model turns out to be a popular trend in the use of teachers (Mzoughi, 2014). Research finding has shown that flipped classroom helps students develop the thinking process, self-directed learning, as well as increased understanding of concept (Berrett, 2012).

One necessary concept of physics that students need to understand, not only in order to describe natural phenomena; which is the energy concept (Driver & Millar, 1986). Energy is one of the fundamental topics in physics, and inevitably applies to daily life. (Ding L., 2007) In addition, energy is an interesting subject at present due to it is a contemporary science (Cari F. et al., 2011), but energy is a difficult concept to understand, and often leads to misconception (Takaoğlu, 2018). According to the abovementioned, in this study gamified flipped-classroom means an adaptation of traditional flipped-classroom. Actually, traditional flipped-classroom has two parts in teaching activity, the first part is out-class, and the other is in-class (Tucker, 2012). Video is always used in out-class, students have to watch video before coming the class, after that, they need to do some activities that related with the video in classroom or in-class part. Gamified flipped-classroom is changed from watching video out-class to play interactive video out-class, this interactive video is created by using game mechanism based. Therefore, the purposes of this study were to investigate students' concept of energy to develop gamified flipped-classroom in concept of energy. This gamified flipped-classroom will be used to facilitate high school students' learning in school science for eliminating students' misconception, enhancing students' concept of energy and promoting science motivation in future study.

2. Literature review

2.1 Foundation of Flipped Classroom and Relevant Study

In 2007, Jonathan Bergmann and Aron Sams who are chemistry teachers were designed and created the flipped classroom model (Tucker, 2012). For flipped classroom, before attending class or out-class students have to understand and summarize the contents by watching video-recorded lectures (Zainuddin, 2018). Videos were frequently used for replacing the conventional classroom lecture in this instructional strategy (Sams & Bergmann, 2013). Likewise, flipped classroom has a unique feature that is the video-recorded lectures and interactive lesson are always available to students. Accordingly, they could reinforce their own learning in a lot of time (Chaipidech & Srisawasdi, 2017). Vice versa, in-class part, instruction is focused on activities that enhances students' thinking skills and constructs their own knowledge. For example, group discussion, group presentation, group argumentation (Keengwe, 2014). Thus, in flipped classrooms the teachers become facilitators and assistants, teachers should be facilitating and advising students to learn by themselves, and give them feedback in class.

The flipped classroom pedagogical method is an emerging active learning trend which will be appropriate alternative choice for contemporary instruction method and it will enters mainstream higher education within the next five years (O'Flaherty & Phillips, 2015). There is several interested researches attention in the flipped classroom along with positive impacts on students, such as achievement, motivation, engagement, and interaction (Zainuddin & Halili, 2016). Chaipidech & Srisawasdi (2016) compared the affective domain of the students, such as perception and engagement between flipped inquiry and conventional flipped mobile. The results showed that students who have learned with the mobile flipped inquiry learning have better perceptions and engagements than students who have learned with conventional flipped mobile.

2.2 Gamification and Flipped Classroom

Flipped classroom model which modifies the learning process is the current trend of education (Zainuddin, 2018). Notwithstanding the flipped classroom has received numerous researches attention and provide various positive results, but not all researches have reported positive results of implementation this pedagogical method. Boevé et al. (2017) compared students' learning behavior between the flipped classroom and a non-flipped-classroom. They found that students' learning

behavior in the flipped classroom does not different to students in the non-flipped-classroom. Furthermore, students only watch videos that provided by teachers outside the class is a recipe for failure. In order to resolve this issue, the flipped classroom was altered by integrating with some innovation, for instance, game mechanism. The new pedagogical method is called the gamified-flipped classroom. The gamified-flipped classroom is based on gamification, in education gamification is defined as the use of game elements or game mechanics in activities, such as points, badges, or leaderboards to enhance people's interest and motivation through competition (Baxter & Wood, 2015). Zainuddin (2018) examines students' learning performance and perceived motivation between a gamified flipped classroom and a non-gamified flipped classroom instructional model. The results showed that students who have learned with gamified flipped classroom have better learning performance and perceived motivation than students who have learned with non-gamified flipped classroom.

Therefore, in this study gamified flipped classroom is a pedagogical method that merges gamification with the flipped classroom, video-recorded lectures was converted into interactive video which video was intervening instructional content and game mechanics.

3. Methods

3.1 Participants

There are 195 participants for this work, all of participants were tenth-grade students who have to attend a physics course in an extra-large public school in Kalasin province at Northeastern, Thailand. Participants age about 15 to 16 years old. They have never learned regarding the energy concept. Moreover, participants never have experience with flipped-classroom before.

3.2 Research Instrument

In this work, the author investigates students' conception of energy by using Energy Concept Assessment (ECA) that is developed by Lin Ding (Ding L., 2007) as research instrument. For this instrument, we selected 10 items of energy concept that consists of six major concepts in energy; kinetic energy, spring potential energy, gravitational potential energy, energy principle, transformation of energy and conservation of energy, from all 28 items, all items are one-tier multiple-choice. After that, we translated them in Thai version.

3.3 Data Collection and Analysis

All participants had 30 minutes to complete conceptual of energy question items. After they had done all items, we analyzed students' conception of energy from students' responses to the question items. Then, we interpreted, and classified students' responses into four categories; scientific conception (SC), SC means the students' responses that shows correct answer in all fragments of the concept; incomplete conception (IC), IC refers to the responses that provides correct answer but not all fragments of the concept; misconception (MC), which means the students' responses that shows incorrect answer, and no conception (NC), NC is the responses that provides either no answer or not clear conception in science (Kanyapasit & Srisawasdi, 2014). Next, a situated learning event was designed for facilitating students to change and revise their misconceptions of energy into scientific conception.

4. Results and Discussion

In figure 1 to 4 show the results of six different concepts related to energy of students' existing conceptions. All figures, we plot the correlation of percentage and conception of energy. Olive green are scientific conception, yellow are incomplete conception, red are misconception and green are no conception.

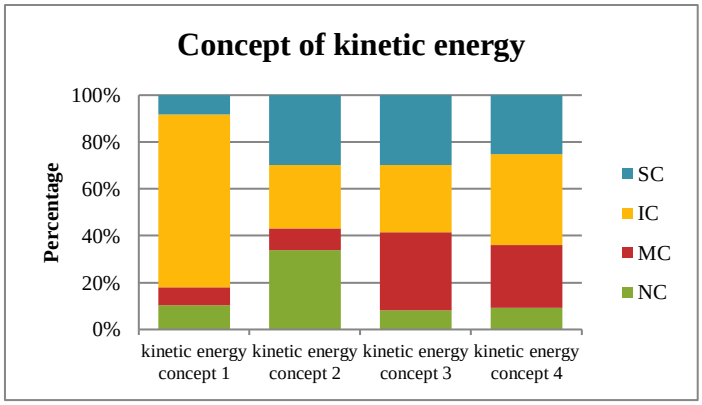

Figure 1. Distribution of students' misconceptions on kinetic energy.

As you can see the figure 1, this is the distribution of students' misconceptions on kinetic energy. In graph, concept 1 means first item and concept 2 is second item and so on, for the first item there are 8.21% of SC, 73.85% of IC, 7.69% of MC, and 10.26% of NC. The second item is 29.74%, 27.18%, 9.23%, and 33.84% for SC, IC, MC, and NC, respectively. The third one, SC is 29.74%, IC is 28.72%, MC is 33.33%, and NC is 8.21%. For the final item, there are 25.13% of SC, 38.97% of IC, 26.67% of MC, and 9.23% of NC. From the percentage of the distribution, we can say that most of students are in incomplete conception and misconception levels of kinetic energy concept.

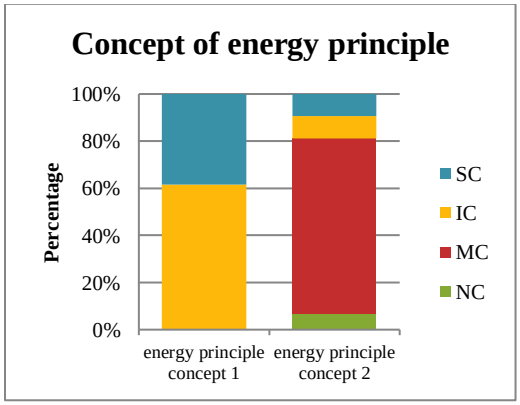

Figure 2. Distribution of students' misconceptions on energy principle.

According to Figure 2, the concept of energy principle has two concepts or two items; the first concept has different percentage of four categories as followed 38.46% of SC, 61.53% of IC, 0% for MC, and NC. The second one, there are 9.23%, 9.74%, 74.36%, and 6.67% for SC, IC, MC, and NC, respectively. To sum up, it is similar to concept of kinetic energy most students are in incomplete conception and misconception levels on energy principle.

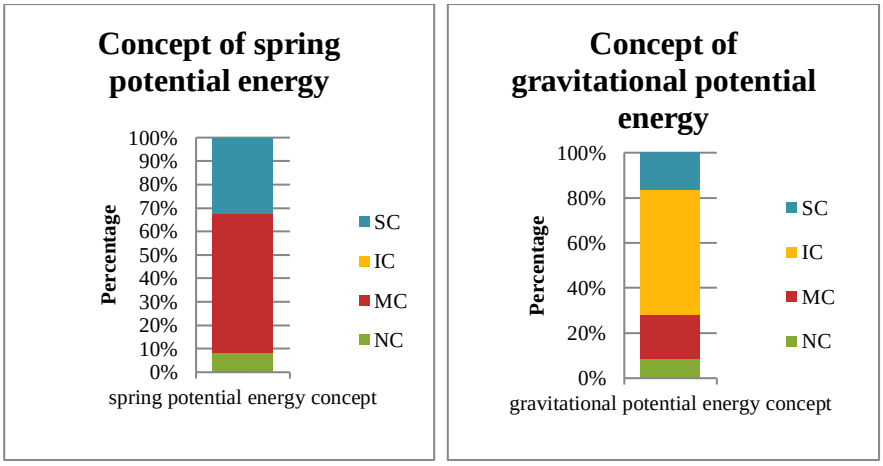

*Figure 3.*The two graphs show distribution of students' misconceptions while the left one is concept of spring potential energy and the right one is concept of gravitational potential energy.

Figure 3, the left graph is distribution of students' misconceptions on concept of spring potential energy and the right one is concept of gravitational potential energy. Spring potential energy, that results are 32.31% of SC, 0% of IC, 59.49% of MC, and 9.23% of NC. Obviously, a half of students are in misconception level. Gravitational potential energy, found that more than a half of the students are in incomplete conception 55.38%, then 19.49% of MC, 16.41% of SC, and 8.72% of NC.

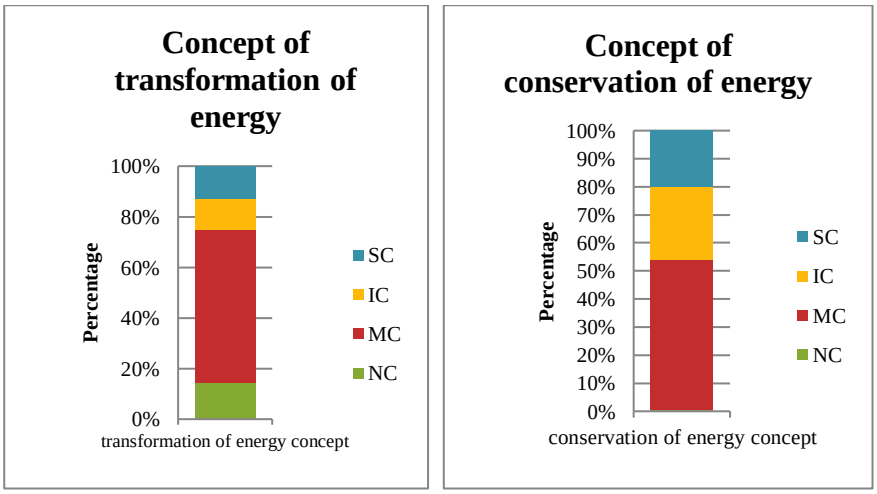

Figure 4. The two graphs show distribution of students' misconceptions while the left one is concept of transformation of energy and the right one is concept of conservation of energy.

As shows in Figure 4, the left graph is distribution of students' misconceptions on concept of transformation of energy. Four categories on this concept are 12.82% NC, 12.31% IC, 60.51% MC, and 14.36% NC. The other one is distribution of students' misconceptions on concept of conservation of energy. It has 20% of SC, 26.15% of IC, 53.33 of MC, and 0.51% of NC. To summarize, for both concepts of transformation of energy and conservation of energy, we discovered that most of students are in misconception level.

In conclusion, from six concepts of energy; kinetic energy, spring potential energy, gravitational potential energy, energy principle, transformation of energy and conservation of energy. The results show that several students are in incomplete conception and misconception in energy concept. To eliminate this problem, we analyze the context of the school to find out how to teach physics. The school has a lot of school holidays, which is align with the flipped classroom teaching strategy, that's why we select to use the flipped classroom to solve the problem.

5. The Proposed Design of Gamified Flipped-Classroom on Energy

The results revealed that most of students are in incomplete conception and misconception in physical science concepts related to energy concept. To enhance students concept of energy through the gamified flipped classroom. We separated classroom in to two parts follow flipped classroom; In-class and Out-class. Out-class part, normally it uses regular lecture video, but for this study interactive video is used instead. Interactive video is created by integrating game mechanics and instructional content of energy was used as a conceptual tool to support student's inquiry learning on energy concept. The video is made up of three videos, each of which is different contents; mechanical energy, energy conservation and energy transformation, and energy transfer. Each of these video takes about five to seven minutes. Moreover, the video will include questions for students to select answer, all students' answer will go to the next video. For all responding each video question, we designed it in the style of the game. It has a mission for students to overcome. The question marks are given to the students through the mission. Ratings are divided into 2 categories. First, plus the score when the students answer the question correctly, then they can answer the next question. Second, it will delete the score when the student answers the wrong question and will answer that question again. All questions are related to the concept of energy. In addition, students will have one supporter to respond correct answer each question. There will be a hint popup button in video with the option to help students to answer question. In addition, each question will take only a few seconds to stimulate the student to answer the question. If students do not answer at the time, the student will be broken in the same way as answering the wrong question. Once students have completed the interactive video, students will receive a score screen. All students have to take screenshots of their own points and keep it for classroom activity. There are 3 videos in each video has different content, including mechanical energy, energy conversion & energy conservation and energy transfer. Every video takes about 6-7 minutes. Vice versa, students not only watched the interactive video outside of the class, but also they were required to complete a gamification laboratory with questions related to these videos and compete to earn scores or points to become a leaderboard. In-class part, in the classroom, teachers divide students into subgroups, each group of students combine their score to be group scores to use in gamified laboratory about energy. In the laboratory, the students use their scores instead of money to buy the device in the laboratory for the experiment. Each of them has different prices. Thus, if students have more points, students can buy more equipment too., students who gotten highest score in interactive video will have special authority in classroom such as, they can select laboratory equipment first. Students will design their procedure to understand about energy concept by themselves the first group of students who can design the correctly procedure and fastest will earn highest score, and then results of students' procedure are analyzed, after that students will communicate or present their results to classmate for sharing the results a group who has an interesting question or presentation also get a score for this part, and finally conclusions, after sharing the results students cooperate to conclude and discuss about energy concept and answer questions related to energy for earning score again. After conclusions section teacher give students feedback and show a group who is a leaderboard. While doing inquiry activity in class, teachers will project a slide regarding with real time score of each student group on the student's scoreboard at all times to motivate each student group to conduct experiments to find the knowledge. Scores will be added to each step of the laboratory which scores come from experiment depend on progression of each group.
After class, student write down learning log using google forms to assess their own learning, moreover, they need to take some pictures of gamified inquiry activity to be evidence of learning in learning log. Gamified flipped-classroom diagram was shown in Figure 5.

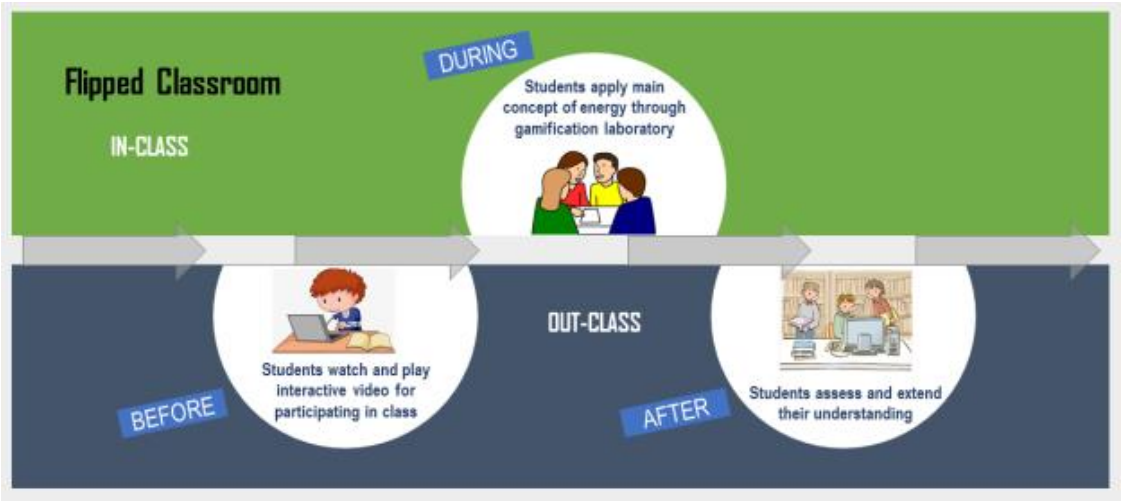

Figure 5. An illustration of gamified flipped classroom with inquiry diagram.

To eradicate this problem, energy is really highly abstract, thus, making a high-abstraction of energy becomes concrete and visible, it is very important. Therefore, the interactive video about energy concept has been designed to address the incomplete conception and misconception that found in the study. Interactive video with gamification regarding to energy would be used pedagogically with flipped classroom to eliminate students' misconceptions and enhance students' conceptions on conception of energy. The interactive video was shown in Figure 6 as examples. If students drag the mouse to an energy monster pop up will shows and links to branches to complete missions in this interactive video. At first, students need to know what kind of energy they are before learning, and what is the definition or meaning of that type of energy? The student must select whether to study kinetic energy or potential energy first, as shown in Figure 6. After learning the preliminary video, students will be allowed to learn with the next video.

Figure 6. Illustration of examples of interactive video on energy concept.

Acknowledgements

We acknowledge the Faculty of Education, Khon Kaen University, for advocating this study. This work was financially supported by The Promotion of Science and Mathematics Talent Teacher (PSMT) from the Institute for the Promotion of Teaching Science and Technology (IPST). Last but not least, we would like to express an extra-large public school in Kalasin province at Northeastern, Thailand, for giving the author an opportunity to do this work.

References

Baxter, R. J., Holderness Jr, D. K., & Wood, D. A. (2015). Applying basic gamification techniques to IT compliance training: Evidence from the lab and field. *Journal of Information Systems, 30*(3), 119-133.

Berrett, D. (2012). How 'Flipping' the Classroom Can Improve the Traditional lacture. *The chronicle of higher Education, 1*(1), 1-14.

Boevé, A. J., Meijer, R. R., Bosker, R. J., Vugteveen, J., Hoekstra, R., & Albers, C. J. (2017). Implementing the flipped classroom: an exploration of study behaviour and student performance. *Higher Education, 74*(6), 1015-1032.

Cari, F. H. & DeBoer, G. E. (2011). Investigating Students' Understanding of Energy Transformation, Energy Transfer, and Conservation of Energy Using Standards-Based Assessment Items. NARST Annual Conference Orlando, FL.

Chaipidech, P. & Srisawasdi, N. (2017). A Flipped Inquiry-based Learning with Mobility to Improving Students' Learning Performance in Science: A Comparative Study. *Proceedings of the 25th International Conference on Computers in Education.* New Zealand: Asia-Pacific Society for Computers in Education

Chaipidech, P. & Srisawasdi, N. (2016). Mobile Technology-enhanced Flipped Learning for Scientific Inquiry Laboratory: A Comparison of Students' Perceptions and Engagement. *Proceedings of the 24th International Conference on Computers in Education*. India: Asia-Pacific Society for Computers in Education.

Ding L. (2007). Designing an Energy Assessment to Evaluate Student Understanding of Energy Topics. (the degree of Doctor thesis), North Carolina State University.

Driver, R., & Millar, R. (Eds.). (1986). *Energy matters: Proceedings of an invited conference: Teaching about energy within the secondary science curriculum*. Leeds [England]: University of Leeds, Centre for Studies in Science and Mathematics Education.

Kanyapasit, P. & Srisawasdi, N. (2014). Development of Digital Game-based Biology Learning Experience on Cell Cycle through DSLM Instructional Approach. *Proceedings of the 22nd International Conference on Computers in Education*. 857-866. Japan: Asia-Pacific Society for Computers in Education

Keengwe, J. (Ed.). (2014). Promoting active learning through the flipped classroom model. IGI Global

Mcnamara, D. S., Jackson, G. T., & Graesser. (2010). Intelligent Tutoring and Games (ItaG). *Gaming for Classroom-Based Learning: Digital Role Playing as a Motivator of Study*, 44-57. Doi: 10.4018/978-1-61520-713-8.ch003

Millard, E. (2012). 5 reasons flipped classrooms work. University Business, 26-29.O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. *The Internet and Higher Education*, 25, 85-95.

Mzoughi, T. (2014) An Investigation Of Student Web Activity In A "Flipped" Introductory Physics Class. *Procedia - Social and Behavioral Sciences*, 191, 235 – 240.

Oblinger, D. (2004). The Next Generation of Educational Engagement. *Journal of Interactive Media in Education, 2004*(8), 1-18.

Sams, A., & Bergmann, J. (2013). Flip your students learning. *Educational Leadership*, 70, 16-20

Schacter, J. (1999). "The impact of ET on students' achievement: what the most current research has to say". ERIC, ed430537, Milken Exchange on education Technology.

Srisawasdi, N. (2012). Introducing Students to Authentic Inquiry Investigation Using an Artificial Olfactory System. In K.C.D. Tan & M. Kim (Ed.), Issues and Challenges in Science 93 Education Research: Moving Forward (pp. 93-106). Issues and Challenges in Science 93 Education Research: Moving Forward.

Takaoğlu, Z. B. (2018). Energy Concept Understanding of High School Students: A Cross-grade Study. *Universal Journal of Educational Research, 6*(4): 653-660.

Tucker, B. (2012). Online instruction at home frees class time for learning. Retrieved from Education Next: http://educationnext.org/the-flipped-classroom/

Zainuddin, Z., & Halili, S. H. (2016). Flipped Classroom Research and Trends from Different Fields of Study. *The International Review of Research in Open and Distributed Learning, 17*(3). 313-340.

Zainuddin Z., (2018). Students' learning performance and perceived motivation in gamified flipped-class instruction, *Computers & Education*, doi: 10.1016/j.compedu.2018.07.003.