Exploring the Use of *Frets on Fire X* (*FoFiX*) in Learning to Learn (L2L)

Jon Paul F. Maligalig
University of the Philippines Diliman
jfmaligalig@up.edu.ph

ABSTRACT

Learning to Learn (L2L), a key competency for practicing lifelong learning, is seldom emphasized in formal education contexts. Supplementary constructivist activities like those in game-based learning methodologies may address this deficiency, as games can trigger the development of L2L skills among learners. This exploratory descriptive case study aimed to determine how *Frets on Fire X* (*FoFiX*), an open source music rhythm game, could be used to facilitate Learning to Learn (L2L) in non-education college students. The procedure of the learning activity was as follows: 1. Briefing the students on how to play the game; 2. Guided gameplay with a song chosen for its low difficulty; 3. Free play with students choosing which instruments and songs to play; 4. Synthesis of gameplay experiences with a learning facilitator through a group discussion. Learning principles were not introduced to the students prior to the activity. The group

discussions were recorded and transcribed for analysis. From their gameplay experiences, students were able to describe techniques they used to learn to play the game. These techniques resembled practical applications of several learning theories and principles. Without a background on these theories and principles, however, the students did not identify these by name. The constructivist design of the learning activity may have helped the students realize practical learning principles from gameplay experiences. Some students also noted that the principles they derived from their experiences could be used in similar, real-life scenarios. The learning activity also functioned as a Preparation for Future Learning (PFL) assessment, a form of dynamic learning assessment that focuses on application and decision-making rather than on-demand performance.

Keywords: Learning to Learn; Frets on Fire X; Game-based learning; Music rhythm game; Learning principles

Introduction

Zeroing in on education issues for the 21st Century, UNESCO was being proactive when it commissioned a study on lifelong learning in 1996. The Delors Report, also known as *Learning: The Treasure Within*, is regarded as an instrumental treatise in global education. The first mention of UNESCO's Four Pillars of Education – Learning to Know, Learning to Do, Learning to Live Together/Learning to Live with Others, and Learning to Be – was made in this report (UNESCO, 1996).

Of the Four Pillars, Learning to Know should be of particular interest to educators in today's thrust for inclusive and high-quality education. Learning to Know involves the development of memory, imagination, reasoning, problem-solving. It also presupposes learning to learn and discover, which allows an individual to benefit from current educational opportunities that occur throughout life (Zhou, 2000). Learning to Learn (L2L), defined as "the ability and willingness to adapt to novel tasks, activating one's commitment to thinking and perspective of hope by means of maintaining one's cognitive and affective self-regulation in and of learning action (Hautamaki, Arinen, Eronen, & Hautamaki, 2002)" is a key competency for practicing lifelong learning. The implication that new tasks trigger and encourage L2L should be a major consideration for educators who wish to develop this competency among their learners.

Ergo, L2L development in this manner is best supported by the constructivist learning paradigm. Here, learning is individualized and constructed from the information provided by the teacher. The teacher then guides the learner in this construction process. With the teacher facilitating the learning process, learners become competent in L2L through reflection on how they construct knowledge and apply these constructs in different contexts (Bada, 2015) (Ertemer & Newby, 2013).

If one is to truly practice lifelong learning, L2L should also be given the same importance in formal, nonformal, and informal education contexts. Education in formal systems, however, has been slow to adapt to this new requirement. While study skills workshops have largely resulted in significantly improving performance (Nordell, 2009), these have not been

institutionalized in most schools and universities. This lack of emphasis on L2L in formal systems may indicate a need to incorporate L2L learning opportunities in nonformal and informal systems. This could be a niche for game-based learning methodologies, as digital and analog games may provide learners with the "novel tasks" mentioned by Hautamaki et. al. that are required to facilitate L2L. In the process of playing a new game, an individual may gain insights on how they learned to play. Moreover, opportunities to synthesize these insights into practical guides on how to learn in similar situations must be taken to foster life-long learning.

This exploratory descriptive case study (performed prior to COVID-19 pandemic lockdowns) aimed to determine how *Frets on Fire X* (*FoFiX*)(Figure 1), an open source music rhythm game similar to *Guitar Hero* and *Rock Band*, could be used to facilitate Learning to Learn in non-education college students; as these students did not come from any education degree program, they did not have any background on learning principles and theories. Any learning observed in and reported by the students, therefore, would have to come from their experiences in learning to play the game.

The study was operationalized with the following specific objectives: (1) describe the procedure of the *FoFiX*-based learning activity, (2) analyze the content of the students' responses during synthesis/group discussion regarding their gameplay experiences, and (3) determine the features of the *FoFiX*-based learning that would make it appropriate for facilitating learning and assessing development of L2L in learners.

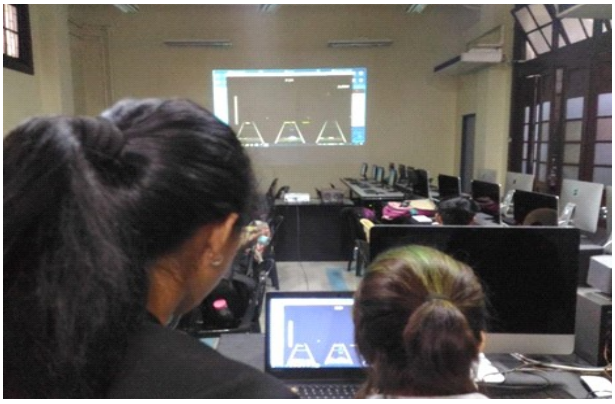

Figure 1. *FoFiX* gameplay on projected and laptop screens.

Review of Related Literature

Before L2L gained prominence with the Delors Report, researchers were considering metacognition, or thinking about learning, as a form of second order learning. Metacognition involves knowledge about what one knows and self-regulation mechanisms (i.e. planning, strategizing, etc.). In this paradigm, teachers often provide for higher-order learning opportunities, but students should also be given opportunities to strategize and reflect on their learning (Black, McCormick, James, & Pedder, 2006).

Both metacognition and L2L are best supported by constructivist learning activities. Through strategizing on their learning, students gain expertise in learning how to learn (Bada, 2015). This emphasis on creating new and context-specific understanding from multiple information sources in order to address a problem is the primary driver of learning in constructivist activities. Assessment in this case is based on how students organize knowledge constructs and how they facilitate thinking and performance when these constructs are used (Ertemer & Newby, 2013).

Assessment of L2L could be a difficult activity if the prevailing notions of educational assessment are followed. Static methods such as conventional testing, which measure knowledge at the time of assessment, have proven to be ineffective measuring tools for L2L. Choice-based assessments, specifically Preparation for Future Learning (PFL), offer better measurement of L2L because of their inherent features: (1) Process-orientation–learner choices are examined, not just the end products of learning, (2) Prospective nature – reveals what students are ready to learn, (3) Consistency with social sciences – examines movement of people, ideas, and money within the system, (4) Avoids reification – considers context and change, (5) Measures a greater range of learning outcomes – is more than fact retrieval procedural application, and (7) Learning choices as standards – describes the process of learning and not just the knowledge acquired (Schwartz & Arena, 2013).

In recognition of the importance of L2L, schools and universities can design opportunities where students are trained in L2L skills. Study skill workshops were created for this purpose; a workshop can have activities

such as self-assessment of current learning techniques, recall learning, active reading, note-taking, and creating concept maps. While student performance among college freshmen improved with their attendance in study skills workshops, it was determined that low-achieving students were least likely to avail of these workshops. Without the ability to self-assess their own learning capabilities, low-achieving students did not perceive a need for study skills workshops (Nordell, 2009).

The use of games and simulations to promote cognitive learning has been a controversial issue, as many studies indicate improved but non-significant gains in cognitive performance (Vlachopoulos & Makri, 2017). However, games and simulations have been found to be enjoyable learning tools that promote collaborative participation, critical thinking and reasoning, and higher-order and metacognitive thinking (Vlachopoulos & Makri, 2017) (Maligalig & Torres, 2011). With the proper pedagogy or andragogy in mind, a game or simulation could be used as the primary educational medium in a constructivist learning activity. Such activities may be helpful in encouraging even low-achieving students to avail of L2L opportunities.

Game-based learning activities that use music rhythm games are good candidates for triggering L2L opportunities in students. In the game *Guitar Hero*, for example, players use a plastic controller that mimics a guitar to play along with songs that serve as game levels. The *Guitar Hero* and *Rock Band* series of games were popular in the late 2000s to mid-2010s and would be familiar to students who grew up during this time period. The experience of playing the game simulates the process of learning to play a guitar quite effectively, as one author shares:

> …I want to say that it is very strange how much playing this game is like learning an actual instrument. Anyone who has struggled with real-world instruments knows the cycle of learning one goes through, and that same cycle repeats itself here… I get better at this game when I sleep. Just like the real thing (Vandenberghe, 2009).

Frets on Fire X (*FoFiX*) is a modified version of *Frets on Fire*, an open source clone of the *Guitar Hero* games. *FoFiX* has been coded to include the

use of computer keyboards or *Guitar Hero*/*Rock Band* controllers and microphones to play lead guitar, bass guitar, drums and is more like the *Rock Band* series of games that followed *Guitar Hero*. The game makes players play along with popular songs by hitting keys on their controllers in time with simplified note markers (circles or rectangles) as they move towards the player. *FoFiX* has been used in educational technology classes in the University of the Philippines Diliman and Los Baños campuses, where students have remarked in teacher and course evaluations that the game makes the content (learning theories) "enjoyable" and "memorable (Maligalig, 2012)."

Methodology

Research Design

The descriptive case study design was used for this study. This research design was deemed appropriate given the exploratory nature of the study; the results would provide insight on the method of using a constructivist game-based learning activity using *FoFiX*. As such, effectiveness and efficiency of the activity was not measured or tested in the course of this study. Nevertheless, the chosen research design will enable refinements to the methods of learning, data gathering, and analysis used in the study; this will provide several jump-off points for future studies to utilize research designs such as quasi-/full experiments and learning ethnographies in order to focus on the nuances of metacognition training using games as simulations.

Participants

Twenty (20) college students from a Philippine state university were invited to participate in the study. All participants were asked to fill up forms giving their free and informed consent to be involved in the study; collected data and findings would be kept confidential and anonymized for purposes of publication. Before each gameplay session started, the participants were reminded of the stipulations in the consent and confidentiality forms. The audio recording of the group discussions also began with the researcher asking for consent to participate and to record the discussions.

The participants came from multiple degree programs: engineering (13), computer science (2), and communication research (5). The participants' educational backgrounds were selected for the absence of formal education and training in learning theories and principles; this was to ensure that the participants' responses would be L2L in nature and not recall past knowledge.

None of the participants were pre-informed as to the exact details of the activity, only that they were going to perform tasks for research purposes. The participants came to the research venue in two groups of nine (9) and 11, respectively. Both groups were isolated from each other to limit their exposure to others' gameplay experiences.

Instruments

Observed behaviors and practices during gameplay were recorded on observation forms (for participant activity and reaction/response) and photographs. These instruments also documented the process of the game-based learning activity. Responses from the group discussions conducted were also included in the observation forms. All observation sheets and photographs were compiled into a data log, which was encoded digitally into a document file for analysis.

Group discussions were done to gather data on the participants' gameplay experiences and the techniques they used to learn to play *FoFiX*. Both groups were subjected to the group discussions. Three general questions were asked during these discussions: (1) How was your experience playing the game?; (2) What techniques did you develop to be able to play the game well?; (3) If someone was learning to play the game, what tips would you give them? Audio recordings of both group discussions were used for documentation.

Data Gathering and Analysis

Gameplay sessions, participant observation, and group discussions were all performed on the same day to ensure easy and immediate data collection. The activities were held in a technology-enabled classroom designed for educational technology courses. The facility featured a large projection screen that allowed the participants to play the game using both the projection and laptop monitor. This setup gave the participants more

options to play better, leading to easier observation of their gameplay behavior.

The learning activity/gameplay sessions were conducted in an informal, relaxed manner. This was done to acclimate the participants to the non-formal/informal nature of the activity. The gameplay sessions were also designed to be constructivist in nature; the participants would be allowed to play on their own with guidance from a session facilitator. The activity had four (4) phases: Instruction, Demonstration, Free Play, and Synthesis. Observations were performed twice, during the Demonstration and Free Play phases. All data collected in observation sheets and photographs were secured for compilation at the end of the Free Play phase.

Group discussions were conducted during the last phase (Synthesis). Each group was subjected to a one (1) hour group discussion where the guide questions were asked. The discussions were held in the classroom where the game sessions were held. A computer-external microphone array was used to record the discussions; for redundancy, a mobile phone was also recording the discussions. The resulting digital audio files were compared for fidelity and the clearer version of each group discussion was selected for transcription.

Data from the observation logs and group discussions were subjected to open coding and categorized. Axial coding was then performed to create themes. These were then synthesized into a general framework on how *FoFiX* could be used to facilitate L2L in nonformal education contexts.

The observations and responses were also thematized to compare these to features of PFL assessments. This would determine whether *FoFiX* as a whole or in part could be used as a PFL assessment. In the case where *FoFiX* would require another assessment method for metacognition purposes, an appropriate PFL assessment would be suggested and discussed.

Results

Learning Activity and Participant Observation

In the instruction phase of the learning activity, participants were first briefed on the nature of the game, its mechanics, and controls used to

play the game. Three (3) sets of keyboards acted as controllers for the participants, simulating lead guitar, bass guitar, and drum instruments. During the briefings, participants were seen to be concentrating on the instructions and eager to start playing.

A demonstration song was then played by the session facilitator during the guided gameplay or Demonstration phase. This was to show the participants how the mechanics and gameplay instructions went together during gameplay. The same demonstration song, which was played on Medium difficulty (deemed easier than Easy due to the natural use of rhythm at this level), was then played by three members of each group; the "no fail" option of *FoFiX* was turned on to remove the "game over" condition triggered if players made a certain number of consecutive mistakes. This was done in order to reduce demotivation among the participants, a common occurrence in previous uses of *FoFiX* in classes (Maligalig, 2012). Clarificatory questions regarding the mechanics and controls by the participants were then addressed by the session facilitator. This continued until all the participants in the group were able to engage in guided gameplay.

The third phase, Free Play, allowed the participants to choose players, band positions (based on the instruments they were simulating), and songs. This was immediately followed by gameplay. Both groups were given 30 minutes to play the game. All participants in both group were able to play multiple times in different band positions. Participants were allowed to experiment with different playing techniques and band positions during gameplay. For both groups, all participants were able to play at least once well before the 30-minute time limit expired; the participants opted to use up all the time, however, as they were observed to be invested and engaged in playing *FoFiX*. Requests to keep on playing after the time limit were accommodated after the last phase of the activity.

The final phase of the activity, Synthesis, involved the group discussions, which acted as the syntheses of the participants' gameplay experiences. Each group was asked to sit together and respond to the facilitator's questions. While each discussion was scheduled for 30 minutes, the participants were able to respond to all questions and follow-ups within 20 minutes.

During both runs of the *FoFiX* learning activity, the participants were openly showing their pleasure in learning to play the game. Despite making many mistakes at first, the players were encouraged verbally (accompanied with gestures showing excitement) by the non-playing participants ("watchers") to perform better. The watchers also offered gameplay advice to the players, especially if the former had finished playing the game for a song or more. Participants who had a difficult time playing a certain band position would opt to try another position in subsequent plays until they found one they performed well. Also observed during the sessions was the identification of the participants with their band positions (eg. "I'm lead guitar next song," "You're our drummer."). This was interpreted as the participants claiming ownership of their performances and recognized their own and others' skills in playing the game. This would be beneficial to the processing of their responses during the Synthesis phase.

Group Discussions on Gameplay Experiences

Participants found the *FoFiX* activity to be "interactive," "enjoyable," and "collaborative," consistent with a similar game-based learning study (Maligalig & Torres, 2011). One participant remarked that it was a "creative way of learning something new" and encouraged its use as an introductory activity for skills training or an icebreaker activity in a regular class. Another participant observed that she was able to play the game better not by memorizing the songs but by paying attention on her behaviors while she played. If these behaviors did not help her in playing better, she would think of new ones that could help and try to implement those in her next turn at play.

It was observed during gameplay that the participants were able to improvise specific techniques in playing *FoFiX*. These included choosing familiar songs for their first play, placing the keyboard controllers flat on a surface as if the participants were typing, anticipating notes in a song by listening to the rhythm of the drums, paying close attention to the built-in feedback mechanism (i.e. "Perfect," "Late") for their timing, and concentrating on getting the first three notes (corresponding to the fore, middle, and ring fingers, the easiest to use) correctly first before trying to hit the fourth and fifth. During group discussions, participants were able to identify the

principles behind these techniques. Participants' playing techniques were thematized as the following:

1. "Hitting the keys until I get it."
2. "Be ready for the notes,"
3. "Remember to press this key for this color."
4. "I was motivated by the elements like animation, music, and score."
5. "Find which notes you hit the most and concentrate on them."
6. "Look for note patterns and anticipate them in similar parts of the song,"
7. "If you get intimidated, you will lose."
8. "The more comfortable I get, the higher I score."

The participants' tips for new players were mostly derived from playing techniques used during the gameplay sessions. Most of the participants gave tips related to Themes 1 (hitting the keys until the player gets used to the action), 3 (color code the notes and remember which keys stand for which colors), 4 (let the music and animation encourage one to get a better score), and 6 (anticipate note patterns and be ready for them). A few participants mentioned Theme 2 tips, which dealt with paying close attention to the notes. Themes 5 and 7 received one (1) tip each from individual participants. One participant mentioned he was poor at these types of games, so he just concentrated on the two notes he could hit consistently. The other participant identified "sitting down and relaxing" as a viable playing tip, adding that real musicians may perform standing on-stage, but they mostly practice songs sitting down.

Discussion

From observations made during gameplay and their responses to the group discussion after, it became clear that the participants were self-conscious and self-aware that they had to learn to play the game to perform better. This was mentioned several times during the group discussions, where some participants mentioned that techniques had to be learned so that they could be used to get higher scores in the game. The constructivist nature of the activity was seen to have enabled the participants to improvise their own

techniques in playing *FoFiX*, which also allowed them to think of and strategize on how they learned to play the game (Bada, 2015). Collaboration, another hallmark of constructivist activities, was also seen during the gameplay as players and watchers alike were engaged in constructing ways on how to better play the game; these ways were then shared during breaks in between songs. This collaborative environment was conducive for the origination, testing, and validation of playing techniques that resulted in constructivist learning among the participants (Ertemer & Newby, 2013).

The participants' techniques and tips for playing the game could also be paralleled to established learning theories and principles. All seven themes of playing techniques have similarities or are practical applications of these theories and principles (Table 1). It was observed that the themes derived from the participants' improvised techniques were similar to established behaviorist and cognitivist learning theories. This implies that the participants were mostly familiar with both paradigms of learning as these were the ones being used in their schooling.

Table 1. Themes of playing techniques and related learning theories/principles.

THEME	PLAYING TECHNIQUE	LEARNING THEORY/ PRINCIPLE
1	"Hitting the keys until I get it"	Trial and Error
2	"Be ready for the notes"	Law of Readiness
3	"Remember to press this key for this color"	Classical Conditioning
4	"I was motivated by the elements"	Operant Conditioning
5	"Find which notes you hit the most and concentrate on them"	Habit Formation
6	"If you get intimidated, you will lose"	Mental Set
7	"The more comfortable I get, the higher I score"	Drive Reduction

Despite the lack of background in education and learning theory, the participants were able to identify practical applications of learning theories and principles within the context of *FoFiX*; however, the participants were unable to explicitly connect these improvised techniques with the names

of established learning theories and principles. This was due to their coming from non-education degree programs.

Some participants spontaneously mentioned that they could see how the way they improvised the techniques used in *FoFiX* could be used in real-life learning scenarios. Of the responses given, learning a new skill was the most cited; one participant remarked that learning to play an actual instrument was easier when one was comfortable, citing his technique that was included in Theme 7. Another participant gave the technique of anticipating patterns (Theme 2) as a method studying for an exam, where a teacher's method of delivering a topic could help one anticipate the test type to be used. He added that in courses where he could not understand a particular concept, he would drill himself to be an expert in others; during an exam, this participant would then have complete confidence in the items within his expertise. This response was included in Theme 5.

It was verified that *FoFiX* could be used as a form of measuring L2L on its own. Observations of the participants and their responses during the group discussions were processed and it was determined that *FoFiX* behaved as a Preparation for Future Learning (PFL) assessment in the constructivist activity. The features of a PFL were observed in the way *FoFiX* enabled the participants to learn how to play the game (Table 2). These observations strengthen the case for using a game such as *FoFiX* as a medium in constructivist L2L activities, as it can be used in the learning activity proper and assessment of L2L (Schwartz & Arena, 2013).

Table 2. Features of *FoFiX* as PFL assessment.

PFL	*FoFiX*
Process-oriented	Enabled learners to feel rewarded with learning, regardless of scores acquired
Prospective	Showed learners how they could learn other content, skills
Consistent with social sciences	Allowed learners to appreciate learning, not just know its concepts
Avoids reification	Provided learners with opportunities to find different strategies to learn

Measures greater range of learning outcomes	Showed learners the value of persistence over failure, inductive strategizing, among other outcomes
Choices as educational standards	Enabled learners to experience learning as a process, not as a concept in a lesson

It should be noted that as a form of dynamic assessment, PFLs should have the flexibility to measure a wide range of learning outcomes and should emphasize learner choice as the primary measure of achievement (Schwartz & Arena, 2013). Simulations allow for this in very specific contexts (Vlachopoulos & Makri, 2017). *FoFiX* was used to simulate the learning process for playing musical instruments, and this "game as simulation" approach supported both the L2L learning process and assessment of this learning (actual performance in the game). *FoFiX* can be considered an appropriate tool for the teaching-learning process of L2L in the context of this study.

Conclusion

This study sought to determine how *FoFiX* could be used for facilitating L2L in college students with no background in learning theories and principles. The documented procedure of the game-based learning activity had the features of constructivist learning activities, which were seen to support L2L opportunities.

From the gameplay experiences of the participants, it was observed that they were able to improvise, test, and implement techniques in playing the game; this was seen as L2L in the context of the activity. Despite the lack of background by the participants in any education course, they were able to identify practical applications of learning theories and principles. These applications were processed into eight (8) themes, with each theme directly relating to a behaviorist or cognitivist learning theory. The participants, however, were unable to identify by name the exact theories and principles that encompassed the techniques they developed to play the *FoFiX*; this was explained by their lack of background in education courses, specifically in learning principles and theories.

FoFiX as used in the activity also had features of a Preparation for Future Learning (PFL) assessment, a type of dynamic, choice-based learning assessment that measures the ability of individuals to learn and not just content knowledge on-demand. The features of PFLs seen in *FoFiX* were seen to complement the constructivist learning nature of the activity and would be a more appropriate method to measure L2L in this context.

In similar cases, the designed learning activity featuring *FoFiX* can be used to provide non-education college students with L2L opportunities. The activity helped students conceptualize and realize techniques play the game, which also led to their recognition of applications of these techniques in real-life learning situations such as exam taking

Further studies must be done to refine the mechanics of the activity and to appropriately measure L2L both quantitatively and qualitatively. This is especially true in post-COVID-19 learning systems, where blended learning modes (i.e. flipped classes) and synchronous-asynchronous remote learning will co-exist with limited face-to-face learning modes; in all of these cases, learners will be expected to have developed L2L skills for self-motivated, independent learning. Experimental studies (with emphasis on one that is longitudinal in nature) may be done to generate effectiveness and efficiency data for future consideration of this game-based learning and evaluation method. Other games, especially more mainstream, commercially available ones, can also be tested in a similar study for their capacity to support L2L in college students. Finally, a study on the faculty acceptability and readiness of using games as simulations for learning activities in college classes must be undertaken to prove if this methodology is ready for mainstreaming in colleges and universities.

Jon Paul F. Maligalig *is an Assistant Professor of Educational Technology at the College of Education, University of the Philippines-Diliman. His research and practice include learning system design, educational media production, game-based learning, and gamification of learning. Maligalig is currently finishing his Ph.D. studies.*

References

Bada, S. O. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research and Method in Education, 6*(1), 66-70.

Black, P., McCormick, R., James, M., & Pedder, D. (2006). Learning how to learn and assessment for learning: A theoretical inquiry. *Research Papers in Education, 21*(2), 119-132. doi:10.1080/02671520600615612

Ertemer, P. A., & Newby, T. J. (2013). Behaviorism, cognitivism, and constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly, 26*(2), 43-71.

Hautamäki, J., Arinen, P., Niemivirta, M. J., Eronen, S., Hautamäki, A., Kupiainen, S., Lindblom, B., Pakaslahti, L., Rantanen, P., & Scheinin, P. (2002). *Assessing Learning-to-Learn: A framework*. Opetushallitus. http://www.oph.fi/english/publications/2002/assessing_learning_to_learn_a_framework

Maligalig, J. F. (2012, December 12). *Game on, UP: Enhancing the University's instruction through game systems*. Retrieved November 5, 2018, from academia.edu:https://www.academia.edu/7397462/Maligalig_2012_Game_On_UP_Enhancing_the_Universitys_Instruction_Through_Game_Systems_UP_Centennial_Professorial_Chair_Lecture_

Maligalig, J. F., & Torres, C. S. (2011, December). Effectiveness of the Computer Game Democracy 2 as an educational medium for teaching development issues in DEVC 10 (Introduction to Development Communication). *Philippine Communication Society Review*.

Nordell, S. E. (2009). Learning how to learn: A model for teaching student learning strategies. *Bioscene: Journal of College Biology Teaching, 35*(1), 35-42.

Schwartz, D. L., & Arena, D. (2013). *Measuring what matters most: Choice-based assessments for the digital age.* Cambridge, Massachusetts: MIT Press.

UNESCO. (1996). *Learning: The treasure within.* UNESCO.

Vandenberghe, J. (2009). I'm holding out for a (guitar) hero. In D. Davidson (Ed.), *Well Played 1.0* (pp. 293-295). ECT Press.

Vlachopoulos, D., & Makri, A. (2017). The effect of games and simulations on higher education: a systematic literature review. *International Journal of Educational Technology in Higher Education, 14*(22).

Zhou, N.-Z. (2000). *A reflection on 'learning to learn': the four pillars of learning and their implications for curriculum reforms.* Retrieved November 3, 2018, from International Bureau of Education UNESCO: http://www.ibe.unesco.org/cops/Competencies/PillarsLearningZhou.pdf