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

A Proposal for Personalized Inquiry-based Flipped Learning with Mobile Technology

Pawat CHAIPIDECH[a] & Niwat SRISAWASDI[b*]
[a]*Science Education Program, Faculty of Education, Khon Kaen University, Thailand*
[b]*Division of Science, Mathematics, and Technology Education, Faculty of Education, Khon Kaen University, Thailand*
[c]*Institute of Learning and Teaching Innovation, Khon Kaen University, Thailand*
*niwsri@kku.ac.th

Abstract: With the benefits of personalized learning environment in providing individual learning, of flipped learning and of inquiry approach for driving students to inquire knowledge in procedural way by using mobile technology, this study developed a personalized flipped open inquiry-based approach, which was based on prior knowledge then they were provided a video related-concept to explore a phenomena and an inquiry question. The effects of the developed approach with mobile technology on secondary school students Physics learning performance and science motivation were investigated. It was found that the students significantly outperformed on the personalized flipped open inquiry-based learning with mobility when compared with other approaches and their intrinsic science motivation were positive. As previously mentioned, this paper extends the proposed instructional strategy and addresses the application proposal by using the mobile device through science laboratory activities about fluid pressure concept.

Keywords: flipped learning, science motivation, open inquiry, personalized learning

1. Introduction

Nowadays, Mobile technology is no longer just a functional accessory: it is an anytime, anywhere device for multimedia, data gathering, data processing and more. The potential benefits of using mobile technology for learning include encouraging anytime anywhere learning, improving social interactions, and enabling a personalize learning experience. For example, Hwang & Chang, (2011) developed a mobile learning environment based on formative assessment to conduct an experiment on a local culture course, the results revealed that the approach could promotes the students' learning attitude and improve their learning achievement.

In science learning, laboratory was involving with an instruction for enhance students' understanding in science concept and develop their science process skills. Numerous researchers suggested that meaningful learning is possible in the laboratory if the students are given opportunities to manipulate equipment and materials in an environment suitable for them to construct their knowledge of phenomena and related scientific concepts. On the other hand, physics is the branch of science concerned with the nature and properties of matter and energy. There're many abstract concepts in physics that couldn't observe processes in real-world experiments and may cause students to misconceptions. In context of Thai science classroom, most of physics teachers used traditional teaching approach in physics lessons. In physics classroom, teacher preferred to use PowerPoint presentation to demonstrate physical processes and present scientific information. According to that class, students were learned science by remembering scientific information that their teachers display in the PowerPoint presentation screen, without interaction with laboratory or any learning tools. Due to this situation, students need more time to learn inside and outside classroom.

The alternative way to applying technology into education is the flipped learning. It is an approach which defined simply as school work at home and homework at school, allow teachers to implement a methodology, or various methodologies in their classrooms. In formal term, Flipped Learning Network (2014) defined that flipped learning is "a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into dynamic, interactive learning environment where the educator guides students as they apply concept and engages creatively in the subject matter”. In classroom, flipped learning with technology could integrate into many subject areas and enhance students’ performance and attitude. For example, Angelini (2016) integrated flipped learning and simulation in course for teachers of English as a foreign language in secondary school and the result shown that students feel positive with this model.

Therefore, this research study the impact of flipped learning integrated into open inquiry with mobile technology on students’ conceptual understanding and science motivation. Moreover, the study compared flipped inquiry learning with mobile technology to hands-on and traditional learning. Its result could have benefits for teaching and learning with technology in science classroom.

2. Research relevant

In recent years, a number of studies about mobile technology have been increased. Many mobile devices were used in class or out class for enhance students’ learning in science (e.g. iPads, smart phones, tablets, and PDAs) and their effect related to cognitive and affective goals in different settings. For example, the students used mobile devices at the school classroom, outdoors, and museums (e.g. Chu et al., 2010; Klopfer et al., 2012). Most of the findings of these studies pointed the added mobile learning is promoting students’ affective (e.g. interest, attitudes) and cognitive domain (conceptual understanding). In terms of promoting students’ understanding, the findings from of these studies showed that the use of mobile devices could enhance students’ conceptual understanding and learning achievement in science (e.g. Chu et al., 2010; Zacharia, Lazaridou, and Avraamidou, 2016). In addition, Looi et al. (2009) also mentioned the fact that mobile learning offers a student-centered learning environment that aims at enhancing personalized and self-directed learning. These positive outcomes could be attributed to different affordances of the mobile devices (e.g. individuality, connectivity, context sensitivity, mobility, immediacy, content provision, collaboration, gaming, and rapid data collection)

Teaching science as inquiry is important pedagogical approach, which allows students to answer questions using data analysis and information exchange (Wang, Wu, Yu, & Lin, 2015). According to Buck et al. (2008), six characteristics represent area in activities and experiments. There are (1) Problem/Question, (2) Background/Theory, (3) Procedure/Design, (4) Results Analysis, (5) Results communication and (6) Conclusions. In addition, the “level” shows the extent to which a laboratories investigation provides guidance in terms of the six characteristics. Each level can be described as follows: level 0 Confirmation; An activity which all six characteristics are provided for students, level ½ Structure inquiry; The laboratory manual provides the problem, procedures, and analysis by which students can discover relationships or reach conclusions that are not already known from the manual, level 1 Guided inquiry; The laboratory manual provides the problem and procedures, but the methods of analysis, communication, and conclusions are for the student to design, level 2 Open inquiry; The problem and background are provided but the procedures/design are for the student to design as well as the analysis and conclusions, level 3 Authentic inquiry; The problem, procedures, analysis, communication, and conclusions are for the student to design.

The appropriate learning tools which considered for effective conceptual change are simulation-based learning environments in science learning (Chen, Pan, Sung, & Chang, 2013). It can allow learners to observe and understand abstract and complex concepts (Chang, Chen, & Sung, 2008). In addition, the capability of computer simulations is closely related to the pedagogy through which they are employed (Flick & Bell, 2000; Srisawasdi & Patcharin, 2015). For science educators, teaching and learning through scientific inquiry is recognized as an instructional practice. The Inquiry-based learning with simulations is an encouraging area for teaching to promote learners’ interaction with the physical and social world in order to develop scientific understanding, explanation, and communication among science ideas. Many educators have found that simulation-based inquiry learning works as an improving process by producing change in the alternative conceptions held by learners (Srisawasdi & Kroothkeaw, 2014; Zacharia & Anderson, 2003), and promoting more qualitative knowledge than formalized knowledge (Suits &

Srisawasdi, 2013), offering students more time to experience on its conceptual aspects. (Zachaia et al.,2008), and promoting positive perception of science learning (Buyai & Srisawasdi, 2014; Pinatuwong & Srisawasdi, 2014).

3. Research Methodology

3.1 Research design

A quasi-experimental pretest-posttest research design was set up to study the impact of three different research conditions on students′ learning performance regarding scientific conceptual understanding and science motivation as shown in Figure 1.

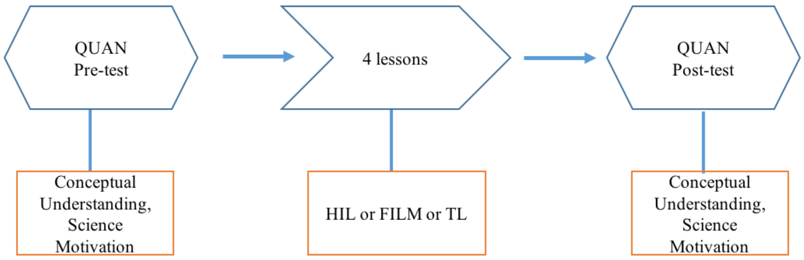

Figure 1. Structure of research design of the study

3.2 Participants

This study recruited the eleventh-grade students of a public secondary school in northeastern region of Thailand. Seventy-nine students from three classes participated in the experiment. Two of the classes were designated as the experimental group A and experimental group B, and the third one was designated as the control group, respectively. The study has not recruited students on a random basis but had to use existing classes. Three classes were selected by a regular science teacher in the school.

3.3 Research Instruments

The tools in this study included a *"Liquid Pressure"* conceptual test and the science motivation questionnaire. The conceptual test consisted of five open-ended conceptual questions that focused on four main science concepts consisting of the following: (i) liquid pressure-depth; (ii) liquid pressure-type of liquid; (iii) liquid pressure-shape of container; and (iv); liquid pressure-gravity, with a perfect score of 10 points. The conceptual test was adapted from Buayai and Srisawasdi (2014). The Cronbach's alpha value was 0.71, showing a high inter-rater reliability of the *"Liquid Pressure"* conceptual test scores. The science motivation questionnaire consisted of 25 items with a five-point Likert scale and was translated from the questionnaire developed by (Glynn, Brickman, Armstrong, and Taasoobshirazi (2011). It consisted of the following: (1) intrinsic motivation (IM); (2) self-determination (SDT); (3) self-efficacy (SEC); and (4) extrinsic motivation such as career motivation (CM) and grade motivation (GM). The questionnaire was translated into the Thai language, and the Cronbach′s alpha value of the questionnaire in the Thai version was 0.92 (Srisawasdi, 2015), implying that the questionnaire had been reliable.

3.4 Data collection and Analysis

The students complete the pre-test of conceptual understanding and science motivation before the learning activity. Then they were participated with four activities (i.e. **(i)** liquid pressure-depth; **(ii)** liquid pressure-type of liquid; **(iii)** liquid pressure-shape of container; and **(iv)**; liquid pressure-gravity). After finishing all of learning activity, the students were administered the conceptual test again as the post-test. Finally, the science motivation questionnaire was provided to them for evaluating their view toward the learning experiences. The statistical data techniques selected for analyzing were Kruskal–Wallis H-test. Then, the Mann–Whitney U-test for independent samples test (a non-parametric equivalent of the independent t-test) was used to run the post hoc pair wise comparisons of averages between groups. Moreover, the Wilcoxon Signed-rank sum test for paired data (a nonparametric equivalent of pair-sample t-test) was used to compare learning gains for all groups. The one-way analysis of covariance (ANCOVA) was used to compare the scores of the three groups in terms of conceptual understanding among the experimental and control groups.

3.5 Learning Materials and Activity

3.5.1 Traditional learning (TL) by lecture-based instruction for CG

The regular teaching method were assigned to students (n = 25) for interact liquid pressure lectures and assignments in a normal classroom. They were usually following the lectures which were given as doublets every week. Each lecture is accompanied by a set of PPT slides. The slides were designed to provide students with full notes of lessons and project in class which concern general principles for effectively using PowerPoint. In addition, the lectures and learning assignments in this class were aligned with series of formative assessment task in every lesson.

3.5.2 Hands-on open inquiry learning (HIL) and interactive lecture for EG#A

In the hands-on open inquiry learning and interactive lecture class (n = 23). Students solved liquid pressure assignments in a normal classroom, with manipulative laboratory equipment and materials that included plastic bottles, beakers, cylinders, plastic tube, glass tube, water, salt water, alcohol, and a manometer.

3.5.3 Flipped inquiry-based learning approach with mobile technology (FILM) for EG#B

Students, in the flipped classroom with the support of mobile technology, were assigned to take responsibility for their own learning with a series of video-based lecture material via YouTube, that are studied prior attend the face-to-face in classroom. The videos provided the content of open-ended driving questions and scientific background and terms or describing related theory as same as the other groups in 6-9 minutes. For each lab section, the additional instructional supports were provided to them (i.e. apparatus set up and diagram illustration of the learning process) via PowerPoint slides, and then they followed their own learning step, and be responsible for their own learning process with simulation on mobile devices, both tablet and mobile phone.

4. Research results and Discussion

4.1 Scientific Conceptual Understanding

To assess the influence of three different learning strategies on high school students' understanding of liquid pressure. To controlling the effect of prior conception, the one-way ANCOVA were used for test the main effect for the experimental groups and the control group. The result of the ANCOVA analysis shown in Table 1. Besides, the Wilcoxon Signed-rank test was used to analyze the differences between pre-test and post-test as shown in Table 2.

Table 1

The ANCOVA results of post-test score for three groups of students

Group	N	Mean (S.D.)	Adjusted mean	Std. error	$F_{(2,67)}$	Post hoc test

						(Bonferroni)
(a) TL	25	3.76(1.88)	4.17	.42	19.658	(b) > (a)
(b) HIL	23	5.09(2.00)	4.62	.42		(c) > (a)*
(c) FILM	31	7.03(1.55)	7.19	.35		(c) > (b)*

$^{*}p = < .05$

The result indicated that there was a statistically significant difference ($F_{(2,67)} = 19.658$, $p = .000$) among three groups. After eliminating the influence of covariance (pre-test), each group was adjusted their mean score, the HIL group had an adjusted mean of 4.62 (SE = .42); the FILM group had an adjusted mean of 7.19 (SE = .35), and the TL group had an adjusted mean of 4.17 (SE = .42) for the post-test measure of conceptual understanding. Regarding to the results, after the instruction (flipped inquiry-based learning with mobile technology), the students in this group were promoted their conceptual understanding on the liquid pressure concept. A Bonferroni's Post HOC Test in Table 1 was employed to test for significance among the teaching methods by conducted using the adjusted means, controlling for any difference prior conceptual understanding. The FILM group were compared to HIL and TL groups revealing a mean difference of 2.571, $p = .000$, and of 3.025, $p = .000$, respectively. This evidence revealed that integration of flipped learning approach with mobile technology could better effect on enhancing students' scientific conception on liquid pressure phenomena.

Table 2

Statistical results on Wilcoxon Signed-rank test for the students' conceptual understanding of liquid pressure

Group	Test	Mean	Mean Rank	S.D.	Posttest-Pretest	N	Z	Sig.	Cohen 's d
TL	Pretest	2.20	32.06	1.19	Posttest<Pretest	4	-2.953	.003*	0.99
	Posttest	3.76	23.00	1.88	Posttest>Pretest	16			
					Posttest=Pretest	5			
					Total	25			
HIL	Pretest	3.91	55.67	1.70	Posttest<Pretest	3	-2.559	.011*	0.64
	Posttest	5.09	35.96	2.00	Posttest>Pretest	16			
					Posttest=Pretest	4			
					Total	23			
FILM	Pretest	2.39	34.77	1.20	Posttest<Pretest	0	-4.879	.000*	3.35
	Posttest	7.03	56.71	1.55	Posttest>Pretest	31			
					Posttest=Pretest	0			
					Total	31			

$^{*}p = < .05$

The results from Wilcoxon signed-rank test revealed that the students in flipped inquiry-based learning with mobility (FILM) and hands-on Inquiry-based learning (HIL), their post-test score showed increased significantly ($Z = -4.879$, $p_{(pre\text{-}post)}$)<.05), ($Z = -2.559$, $p_{(pre\text{-}post)} < .05$) and a traditional learning class (TL) have post-test greater than pre-test score ($Z = -2.953$, $p_{(pre\text{-}post)} < .05$). However, the students in FILM class were highest score when compared with others, as shown in Table 2. This indicated that when the flipped inquiry-based learning had been integrated with the computer-simulated visualization into the science learning of liquid pressure, there had been a significant impact on conceptual understanding. Similar conclusions were found in an engineering course (Mason, Shuman, and Cook, 2013) and the students' performance reported that all assessment was significant difference found with students in the flipped class when compared to a traditional group (Gonzalez-Gomez et al., 2016). In addition, Davies et al., (2013) found that the flipped classroom approach allowed students to learn course content by themselves, and to make better use of their time, improving their perception toward the class. Obviously in this study, the significant differences were found among three groups (FILM, HIL, and TL). Particularly students' conceptual understanding was significantly higher when a flipped model integrated to inquiry-based learning with visualize simulation on mobile devices was followed. Similar case was found when use the technology, Srisawasdi and Kroothkeaw (2014) said that students' conceptual score for pre-test, post-test, and retention test were significantly different and they increased conceptual understanding after participated with simulation class.

4.2 Science Motivation

In Table 3, the post-examination score of science motivation were compared through Kruskal-Wallis Test and Mann-Whitney U-Test. Moreover, the Wilcoxon Signed-rank test were used for compare pre- and post-examination scores of science motivation after the interventions in three groups, displayed in Table 4.

Table 3

The Results of Kruskal-Wallis H-test and Mann-Whitney U-Test for the post-examination scores of science motivation

	Post-questionnaire			Chi-square	Post hoc comparison
	TL	HIL	FILM		
IM	a=17.32[23.44](2.46)	b=18.65[43.13](2.74)	c=19.58[51.03](2.51)	20.875	c>b>a*
CM	d=17.88[39.49](2.68)	e=18.00[41.35](2.88)	f=17.68[39.42](2.71)	.114	e>d>f
SDT	g=15.80[27.14](3.01)	h=17.04[37.07](2.99)	i=18.71[52.55](2.31)	17.818	i>h>g*
SEC	j=15.28[26.48](2.72)	k=15.87[35.54](3.14)	l=16.81[54.21](3.34)	21.684	l>k>j*
GM	m=17.64[35.62](3.11)	n=18.91[40.82](3.33)	o=18.39[40.82](3.65)	1.550	n>o>m

**p* = < .05
Note: xx.xx[yy.yy](zz.zz) refers Mean[Mean Rank](S.D.)

Regarding to IM (Chi-square=20.875, p= .000< .05) and SDT (Chi-square=17.818, p= .000< .05), and SEC (Chi-square=21.684, p= .000< .05), there was a significant difference in terms of post-intervened science motivation for the three groups as showed in Table 5. Based on the post hoc analysis with Mann-Whitney U-Test for multiple comparisons, the results indicated that the flipped inquiry-based learning (EG#B) had exhibited the most positive effect on increasing the students' intrinsic motivation (IM), self-determination (SDT), and self-efficacy (SEC). To summarize the science motivation phenomenon, the results indicated that the students had exhibited better intrinsic motivation, self-determination, and self-efficacy after they had interacted with the flipped inquiry-based learning with visualized simulation.

Table 4

The Wilcoxon Signed-rank test for the students' science motivation pre- and post- test

Scale	Group	Pre-questionnaire	Post-questionnaire	Wilcoxon signed-rank test	
		Mean (S.D.)	Mean (S.D.)	z-score	Sig.
IM	TL	17.32(2.64)	17.32(2.46)	-.203	.634
	HIL	17.87(2.55)	18.65(2.74)	-1.994	.049*
	FILM	18.32(2.09)	19.58(2.51)	-2.117	.034*
CM	TL	16.56(2.73)	17.88(2.68)	-1.941	.052
	HIL	17.04(3.10)	18.00(2.88)	-.769	.442

	FILM	17.29(2.65)	17.68(2.71)	-.325	.745
SDT	TL	15.72(2.57)	15.80(3.01)	-.557	.672
	HIL	16.39(3.01)	17.04(2.99)	-2.104	.039*
	FILM	16.42(2.36)	18.71(2.71)	-1.987	.047*
SEC	TL	13.80(1.73)	15.28(2.72)	-.1.110	.067
	HIL	15.04(2.87)	15.87(3.34)	-.121	.936
	FILM	14.32(3.11)	16.81(3.34)	-3.124	.002*
GM	TL	16.72(2.61)	17.64(3.11)	-.702	.483
	HIL	19.04(2.76)	18.91(3.33)	-.131	.896
	FILM	17.23(3.69)	18.39(3.65)	-1.040	.299

$^{*}p = < .05$

In Table 4, the Wilcoxon signed-rank test analysis found that there were significant differences between pre- and post-test of students in TIL and FILM groups which consisted of IM (Z = -1.994, *p* = .049, Z = -2.117, *p* = .034), SDT (Z= -2.104, *p* = .039, Z = -1.987, *p* = .047). Furthermore, a SEC dimension was only statistically significant difference in HIL group (Z = -3.124, *p* = .002). Regarding to the result, the FILM environment could increase students' internal motivation (IM, SDT, and SEC) after participated with this method when compared to others. This results perhaps due to students' prior experience were encountered with lecture-based in regular science classroom. Moreover, for FILM setting, the students were provided online video on YouTube for watch and learn by themselves before class by the teacher and when the activities in face-to-face classes in FILM model, students allowed to participate with visualized simulation on their mobile devices. Similar studies, Hwang and Chang (2011) claimed that a mobile learning environment is not only student's achievement but also promotes their interest and attitude to learn science. In addition, the integration of computer-based laboratory could motivate students to learn science potentially (Srisawasdi, Moonsara, and Panjaburee, 2013). In contrast, in FILM class, the students' career motivation (CM) and grade motivation (GM) were not significance differences with other groups. This results perhaps due to in online video and activities are not explicitly show how to get a good work in the future after learn science and get scores during activity in class.

5. A proposed Personalized Flipped Open Inquiry-based Science Learning

5.1 Overall Learning Design with mobile technology

From attempts to improve students' learning in science, Open-inquiry science learning is processes of scientific inquiry which can lead students to work with scientific method and promote students' scientific thinking (Srisawasdi, 2015). Moreover, Srisawasdi (2012) developed the combination of open-inquiry science learning with computer-based laboratory environment components and teacher-student role in inquiry activities. In order to integrate the flipped learning approach, the characteristic (1) Problem/Question and (2) Theory/Background were transformed into video session that students watch online outclass. In addition, the conceptual test was used for let the students probe their prior knowledge before learning in the out of class session. In class session, the learning process of simulation-based open inquiry (Srisawasdi & Kroothkeaw, 2014) was adapted to characteristic (3) Procedures/Design with the aim to promote students' science motivation and enhance their conceptual learning. The pedagogy has been produced and shown in Figure 3.

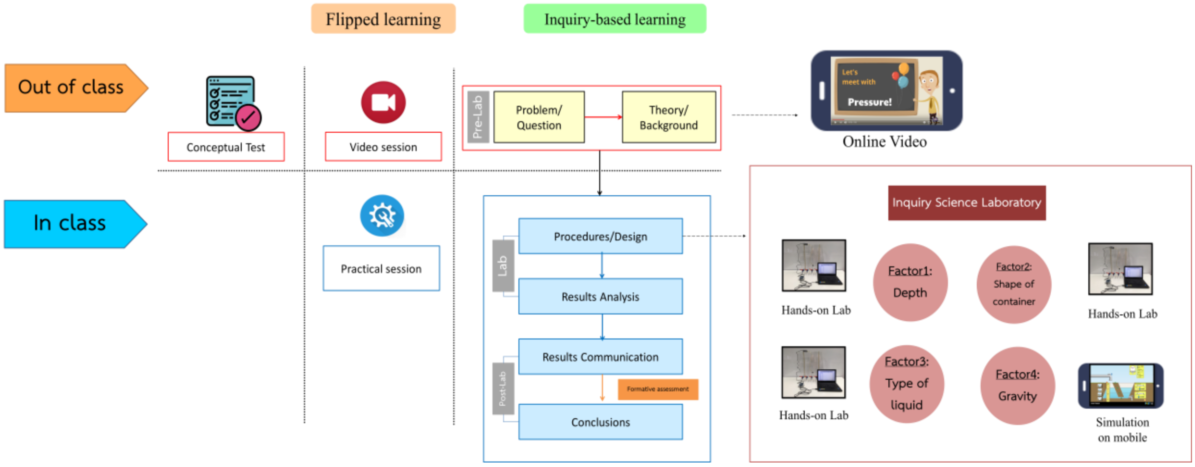

Figure 3. The Flipped inquiry-based learning with mobile technology

5.2 Teaching Materials and Learning Environment

5.2.1 Hands-on open inquiry laboratory and simulation on mobile device

In the personalized flipped classroom with the support of mobile technology, students were assigned to take responsible for their own conceptual testing and a series of video-based lecture material via YouTube, that are studied prior attend the face-to-face lab section. The videos provided the content of open-ended questions and scientific background and terms or describing related theory in 6-9 minutes. After the student done the conceptual test and gain each concept score in the out of class session, then in class session they were assigned to hands-on open inquiry laboratory about liquid pressure in the concept that they were low score, by manipulative laboratory equipment and materials that included the container, laptop, pressure sensor, water, oil, and glycerol as shown in Figure 4.

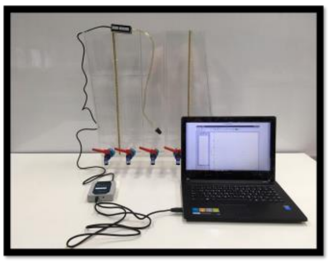

Figure 4. Learning materials for hands-on activities in flipped open inquiry classroom

For a lab station, Regarding the open-inquiry learning process, the step-by-step instructions for hands-on lab sections were given on how to set up the apparatus via the slides, but the lab procedures, data collection and analysis, and conclusion were not provided for the students. Then they take control of their own learning pace, and be responsible for their own learning process with simulation on mobile devices, both tablet and mobile phone, as showed in Figure 5.

Figure 5. An Online video on YouTube about diving and pressure via mobile devices(Left) and Under Pressure Simulation (Right)

5.2.2 *A STEM activity (the gravitational vortex power plant)*

After the students finish the learning processes in the inquiry activities they were allowed to a STEM station for design a model in order to produce electricity from the vortex as shown in figure 4. The gravitational vortex information was on YouTube which provided by the teacher. Moreover, the gravitational vortex power plant model also proposed by Wanchat et. al. (2013). This hydroelectric power plant model could produce electricity by let the water flow through the turbine which connected to a dynamo (see Figure 6). The students have to use their learning experiences that gain from lab stations about the relationship between pressure, depth, type of liquid, shape of container, and gravity to design this model.

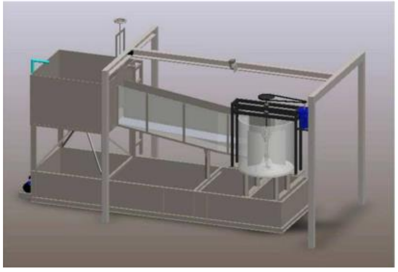

Figure 6. The gravitational vortex model for produce an electricity in a STEM activity

6. Conclusion

This study proposed a personalized flipped open inquiry learning for enhance science learning. The approach mainly provided learning activities that encourage students to inquire scientific understanding. The inquiry activity was adapted for learning about static fluid pressure concept. The results showed that students who were investigated conceptual understanding through the two-tier test after participating with the proposed approach were significant differences among three groups; it indicated that students in the experimental group which studied with the flipped inquiry-based learning with mobile technology approach had better conceptual understanding about liquid pressure phenomena more than studied with hands-on open inquiry learning, and traditional method. Moreover, students' conceptual understanding scores between pre-test and post-test among three groups was also significant differences. To explore students' science motivation, a 25-item science motivation questionnaire included intrinsic motivation (IM), self-determination (SDT), self-efficacy (SEC), career motivation (CM), and grade motivation (GM) was used (Glynn et al., 2011). In this study, the results of Kruskal-Wallis H test showed the significant differences among three groups in internal dimension motivation (e.g. IM, SDT, and SEC), in a FLIM class had the most positive effect. Thus, the results indicated that students in flipped inquiry-based learning class have changed science motivation over the flipped inquiry learning with mobile technology experience. These results can imply that the flipped inquiry learning can be effective in fostering students' internal motivation and conceptual understanding to learning science.

However, the limitations of this study include a limited capability of the inquiry activities, which was once prepared by teacher in advance of the course. Finally, it is also interesting to study the effects of this proposed approach on other topics since their natures are varied, while the generalization of this study would be limited.

Acknowledgements

This work was supported by Science Education Program, Graduate School, Faculty of Education, Khon Kaen University, Khon Kaen, Thailand. The authors would like to express sincere thanks to Chiang Yuen Pittayakhom school for all participants.

References

Angelini, M. L. (2016). Integration of the pedagogial models "Simulation" and "Flipped classroom" in teacher instruction. *SAGE journal*, 1-8.

Buyai, J., & Srisawasdi, N. (2014). An Evaluation of macro-micro representation-based computer simulation for physics learning in liquid pressure: Results on students' perceptions and attitude. In C.-C. e. Liu (Ed.), *the 22nd International Conference on Computers in Education* (pp. 330-338). Japan: Asia-Pacific Society for Computers in Education.

Chu, Hui-Chun; Hwang, Gwo-Jen; Tsai, Chin-Chung. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers & Education* (55), 1618-1627.

Davies, R. S., Dean, D. L., & Ball, N. (2013). Flipped the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Educational Technology Research and Development, 61*(4), 563-580.

Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science Motivation Questionnaire II: Validation With Science Majors and Nonscience Majors. *Journal of Research in Science Teaching, 48*(10), 1159-1176.

Gonzalez-Gomez, D., Jeong, J. S., Rodriguez, D. A., & Canada-Canada, F. (2016). Performance and perception in the flipped learning model: An initial approach to evaluate effectiveness of anew teaching methodology in a general science classroom. *Journal of Science Education and Technology* (26), 450-459.

Hwang, G.-J., & Chang, H.-F. (2011). A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. *Computers & Education* (56), 1023-1031.

Klopfer, E., Sheldon, J., Perry, J. and Chen, V. H.-H. (2012). Ubiquitous games for learning (UbiqGames): Weatherlings, a worked example. *Journal of Computer Assisted Learning*, 28, 465–476.

Looi, C.-K., Seow, P., Zhang, B., So, H.-J., Chen, W. and Wong, L.-H. (2010), Leveraging mobile technology for sustainable seamless learning: a research agenda. *British Journal of Educational Technology*, 41, 154–169.

Mason, G., Shuman, T and Cook, K. (2013), Comparing the Effectiveness of an Inverted Classroom to a Traditional Classroom in and Upper Divison Engineering Course. *IEEE Transactions on Education*, 56(4), 430-435.

Pinatuwong, S., & Srisawasdi, N. (2014). An investigation of relationships between biology attitudes and perceptions toward instructional technology in analogy-based simulation on light reaction. In C.-C. e. Liu (Ed.), *the 22nd International Conference on Computers in Education* (pp. 149-152). Japan: Asia-Pacific Society for Computers in Education.

Srisawasdi, N. (2014). Developing Technological Pedagogical and Content Knowledge in Using Computerized Science Laboratory Environment: An Arrangement for Science Teacher Education. *Research and Practice in Technology Enhanced Learning*, 9(1). 123-143.

Srisawasdi, N., & Kroothkeaw, S. (2014). Supporting students’ conceptual development of light refraction by simulation-based open inquiry with dual-situated learning model. *Computers in Education, 1*(1), 49-79.

Srisawasdi, N., & Panjaburee, P. (2015). Exploring effectiveness of simulation-based inquiry learning in science with integration of formative assessment. *Computers in Education, 2*(3), 323-352.

Srisawasdi, N., Moonsara, R., & Panjaburee, P. (2013). Students’ Motivation of Science Learning in Integrated Computer-based Laboratory Environment. In S. C. Tan (Ed.), *the 21st International Conference on Computers in Education.* Indonesia: Asia-Pacific Society for Computers in Education.

Suits, J. P., & Srisawasdi, N. (2013). Use of an Interactive Computer-Simulated Experiment To Enhance Students’ Mental Models of Hydrogen Bonding Phenomena. In J. P. Suits, & M. J. Sanger, *Pedagogic Roles of Animations and Simulations in Chemistry Courses* (Vol. 1142, pp. 241-271). American Chemical Society.

Wanchat, S., Suntivarakorn, R., Wanchat, S., Tonmit, K., & Kayanyiem, P. (2013). A Parametric Study of a Gravitation Vortex Power Plant. *Advanced Materials Research*, 805-806, 811-817.

Zacharia, Z. & Anderson, O.R. (2003). The Effects of an Interactive Computer-Based Simulation Prior to Performing a Laboratory Inquiry-Based Experiment on Students' Conceptual Understanding of Physics. *American Journal of Physics, 71*(6), 618.

Zacharia, Z. C., Lazaridou, C., & Avraamidou, L. (2016). The use of mobile devices as means of data collection in supporting elementary school students’ conceptual understanding about plants. *International Journal of Science Education, 38*(4), 596-620.

Zacharia, Z. C., Olympiou, G., & Papaevripidou, M. (2008). Effects of experimenting with physical and virtual manipulatives on students' conceptual understanding in heat and temperature. *Journal of Research in Science Teaching, 45*(9), 1021-1035.