Students' Sense Making and Effort towards Project – Based Learning in Learning Physics

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Abstract

The purpose of this research was to seek the effectiveness of Project – Based Learning (PBL) (i.e., egg drop project) towards students' sense making and effort in learning physics (i.e., momentum, impulse and impulsive force). This research was conducted in Tuaran (Urban) and Kota Marudu (Rural) in Malaysia. A total of thirty- eight (38) form four students (i.e., 17 male and 21 female students) were used in the study. Data used in the study were collected using the Colorado Learning Attitude about Science Survey (CLASS) – sense making and effort Category. Respondents were required to response to the survey instrument based on a five point Likert scale before (pre-survey) and after (post-survey) in the implementation of PBL. Data collected were analysed using Statistical Package for Social Science Version 20.0 for windows (SPSS) to compare the students' pre-survey and post-survey responses. Wilcoxon signed ranks test results showed that sense making and effort of overall students for both schools in total, gender (i.e., male and female) and location (i.e., urban and rural) have positive significant difference in median values. In addition the second analysis which is the paired samples-t-test results showed that overall students for both schools in total, gender (i.e., male and female) and location (i.e., urban and rural) have positive significant difference in mean values as well. Therefore study revealed that through PBL-egg drop project, students could relate physics concepts; momentum, impulse and impulsive force into real life situations, engaged students' sense making and effort in learning physics and changed students' perception towards physics.

Keywords: Project-Based Learning, Physics Education, Egg Drop Project, Sense Making, Effort

Introduction

Physics always has been viewed as hard and boring subject by the students who enroll physics in school (Erinosho, 2013). Students have difficulties to connect physics concepts they learn in class with the real world situations which they think that physics is beyond their capabilities and abilities to comprehend (Kovanen, 2011). According to Mchunu & Imenda (2015), knowledge

cannot be transmitted to one another but need to be developed by the students themselves through learning and environmental experiences. Teacher needs to take control how the students think about physics, when students come to the course with more sense making and effort are likely to have higher learning gain (Perkins, Gratny, Adams, Finkelstein, & Wieman, 2004).

Sense making carries a concept of knowing enough to make an appropriate decision based on past experience (Snowden, 2008). Meanwhile, effort is defined as an amount of energy and time individual spent to complete a particular task (Carbonaro, 2005). Sense making is correlated with effort to understand connections to act effectively (Snowden, 2008). Hands on activities for physics in everyday life course give a positive effect towards students' sense making and effort (Harlow, Landau & Bailey, 2014). Male and female students' desire to learn increase when teachers provide them with teaching that involved real world applications and connection to careers (Lock, Castillo, Hazari & Potvin, 2015). Meanwhile, urban students have higher achievement in academic performance compared to rural students towards science subject which urban students are more encouraging than the rural students (Agbaje & Awodun, 2014). In general, rural students are left behind in terms of academic achievements as well as lower educational aspirations in comparison with urban students (Salmiza, 2014).

Literature Review

The implementation of Project – Based Learning (PBL) in physics related course has positively increase students' interest towards physics (Liu, 2014). Students' interest and effort are related to each other, when students have an interest towards physics, students' effort followed (Net Industries, 2016). PBL emphasises on active engagement towards students' effort for a period of time (Holubova, 2008). In addition, PBL makes students spend a lot of time working in a group to gather information from the internet and discussed among groups members (Wong, 2006). Students' effort throughout PBL influences the outcome of the project's result (Autodesk Digital STEAM Workshop—Egg Drop—Instructor's Guide, 2011).

PBL is adopted constructivist learning theory where students construct their own knowledge based on experience through actual projects (Holubova, 2008). Constructivism emphasises more on to construct knowledge rather than to transmit and record information given from another person (Applefield, Huber & Moallem, 2001). PBL serves authentic learning chances and makes students to investigate various contain areas (Meyer & Wurdinger, 2016). In addition, PBL provides opportunities for students to investigate and gather information towards meaningful questions as

well as to think critically (Antic & Spasic, 2012; Fauziah, 2011). After long investigation, students may answer the question on their own especially problems they have encountered earlier (Intel Teach Program, 2007). PBL helps to develop students' ability to collaborate well with others, communicate, be a starter and manage own-self (Noramdzan, Aede, Audu & Salwa, 2015). Students must communicate and cooperate with others to construct knowledge and enlarge their views (Jia, 2010). Moreover, PBL leads students learn to work as a team and to be researchers when intervene with technologies, materials and various tools (Holubova, 2008).

Female students are impacted more with PBL compared to male students (Vaz, Quinn, Heinricher & Rissmiller, 2013). Female students seem to be more optimistic, less frustrated, more confident and satisfied with their experiences towards project intervention in comparison with the male students (Lamoureux, Behesti, Cole, Abuhimed & AlGhamdi, 2013). Moreover, female students have higher sense making and efforts towards the implementation of PBL which during PBL female students overwhelmed, gained a lot of experience, felt challenging and have problem with time management (Zastavker, Ong & Page, 2006).

Meanwhile, integrated PBL leads urban students to do their own research and share the information they have with their friends in class (Harrigan, 2014). In addition, according to New York City (NYC) Department of Education (2009), projects improve urban students' understanding of scientific inquiry that leads them to investigate important ideas and questions as well as draw conclusions within the project. PBL – high tech program gives an impact towards rural school which this program made the students to think and have understanding more about computing and technology (North Daviess School Corporation, Indiana, USA & Education Networks of America, 2008).

Egg drop challenge is part of *Drexel-SDP GK-12- activity in* Drexel University, Philadelphia, USA to excel in Astronomy Module two which students act as a Mars Rover Engineers to drop and landed the rover on the planet from a spacecraft safely (Kusic & Garbarine, 2008). According to Lost Angeles Unified School District, USA (2012), egg drop project helps students to enhance their understanding towards physics especially momentum and impulse concept. Hands-on projects such as egg drop project helps students to have better understanding in physics where students work in teams and build egg container using balsa wood sticks, glue and raw egg and drop the unit from a certain height and place on a target zone (Sridhara, 2013). This project is a great success as students can relate their understanding more about the concepts into real life

situations which students free to apply their own skills and knowledge to design and build the egg's protector instead of taking order from manual book (Yusfi, 2014).

Research Objectives

The main objectives of this study were:

- To compare students' sense making and effort towards physics before and after the implementation of Project-Based Learning (egg drop project).
- To compare male and female students' sense making and effort towards physics before and after the implementation of Project-Based Learning (egg drop project).
- To compare urban and rural students' sense making and effort towards physics before and after the implementation of Project-Based Learning (egg drop project).

Research Methodology

This study employed a quantitative approach in its methodology and designs with pre-survey - post-survey administered to the experimental group and none to the control group (Encyclopedia of Research Design, 2010). Sample collected from two schools situated in Tuaran District which represented an urban area (School A) and Kota Marudu District which represented a rural area (School B). Thirty – eight (38) Form Four (4) science students were involved in this study who took physics. As students were the respondents for this research, data could be extracted from two different places to measure the effectiveness of the implementation of PBL to improve students' sense making and effort towards physics. Researcher used the same methodology for both schools for this study. Table 1 showed the overall total of sample in both schools:

Table 1: *Students' Distribution from Both Schools*

School	Gender		Total
	Male	Female	
A	8	12	20
B	9	9	18

Survey Questionnaire

According to Adams, Perkins, Podolefsky, Dubson, Finkelstein & Wieman (2006), students' sense making and effort in physics can be measured using The Colorado Learning Attitude about Science Survey (CLASS) – sense making and effort category. Each item statement was based on a five-point Likert Scale as follows: Strongly Agree-5; Agree-4; Neutral-3; Disagree-2; and Strongly

Disagree-1 (Adams, Perkins, Podolefsky, Dubson, Finkelstein & Wieman, 2006). All seven (7) statements passed the reliability and validity tests conducted by the University of Colorado Physics Education Research Group (Mistades, Reyes & Scheiter, 2011). Each item statement was translated to Malay Language in this study. Before the intervention, a pilot test was conducted and the Cronbach's Alpha (α) coefficient value for CLASS – sense making and effort category was α = 0.741. Result revealed that CLASS – sense making and effort category instruments were reliable to be used in the data collection. Students conducted the pre-survey and post-survey before and after the intervention by using exactly the same questionnaires.

Implementation of Project-Based Learning (Egg Drop Project)

Students worked in a group project where each group consisted of three (3) or four (4) students. Students relate the physics concepts within the physics curriculum content namely as momentum, impulsive and impulsive force to build an egg protector by using the fundamental materials such as toothpicks, superglues and a raw egg provided by the facilitator. Each group was given two weeks to design and build the egg protector, discuss project-related issues and questions among group members and the facilitator. At the end of the two weeks, students present their best model of the project and egg drop launching session was conducted from the two-level of building block. Each group need to make sure the raw egg not break after landed on the ground.

Results and Discussion

Students' Sense Making and Effort towards Physics

Parametric analyses can be performed well with continuous data which obtained from small samples greater than twenty (20) (Frost, 2015). At the same time, it is best to employ the 'paired-samples t-test' if the data is in normal distribution, and the 'Wilcoxon Signed Rank test' if the distribution is not normal and in a small number of the sample to investigate differences between groups (Coakes, 2005). In this study, Wilcoxon signed ranks test was used to analyse the median data and paired sample t-test to analyse the mean data (Frost, 2015). Statistical Package for Social Science Version 20.0 for windows (SPSS) was used to analyse the data.

Wilcoxon signed-ranks test results from Table 2 showed that overall students in both schools in total have a statistically significant difference between the median value level Likert scale degree of agreement for post-survey and pre-survey (Z = -3.70, p = 0.00*). Indeed, median value for post-survey was 4.29 and pre-survey was 3.86. Paired samples *t*-test results from Table 2 showed that

overall students for both schools in total have a statistically significant difference between the mean value level Likert scale degree of agreement of post-survey (M = 4.26, SD = 0.38) and pre-survey (M = 3.85, SD = 0.38) that the students have, $t(37) = 9.04$, $p = 0.00$*, $p \leq 0.05$.

Table 2: *Results on Students' Sense Making and Effort for Both Schools in Total*

Likert Scale Value	Wilcoxon Signed Ranks Test		Paired Samples t-test	
	Pre-survey	Post-Survey	Pre-survey	Post-survey
Mean			3.85	4.26
SD			0.38	0.38
Median	3.86	4.29		
Z / t value	Z = -3.70		t(37) = 9.04	
p – value	0.00*		0.00*	

**is significant at $p \leq 0.05$*

These findings are in line with Liu (2014) stated that during PBL intervention, students showed a positive sense making and effort by building a Pratt bridge model which in four weeks period, students made initial plans, discussed related issues and questions, experimenting and presenting their final Pratt bridge model. Similar findings are encountered by Muzzarelli (2007) stated that PBL served opportunities towards students to actively making investigation, discussed related issues and questions among group members, demonstrating, experimenting and building a file – folder bridge which students collaborated in a group and spent their energy for three weeks to complete the task. Moreover, according to Sridhara (2013), engineering students showed a positive sense making and effort towards egg drop project to understand the principles and applications of Calculus – Based Dynamics.

Gender' Sense Making and Effort towards Physics

Wilcoxon signed-ranks test results from Table 3 showed that male students for both schools in total have a statistically significant difference between the median value Likert scale degree of agreement for post-survey and pre-survey ($Z = -3.52$, $p = 0.00$*). Meanwhile, the median value for post-survey was 4.29 and pre-survey was 3.86. Female students for both schools in total also have significant difference between the median value Likert scale degree of agreement for post-survey and pre-survey ($Z = -3.70$, $p = 0.00$*). The median value for post-survey was 4.29 and pre-survey was 3.86.

Paired samples *t*-test results from Table 3 revealed that male students for both schools in total have a statistically significant difference between the mean value level Likert scale degree of agreement of post-survey (M = 4.36, SD = 0.31) and pre-survey (M = 3.89, SD = 0.32), $t(16) = 7.88$, $p = 0.00$*, $p \leq 0.05$. Meanwhile, female students for both schools in total have a statistically significant difference between the mean value level Likert scale degree of agreement of post-survey (M = 4.18, SD = 0.42) and pre-survey (M = 3.81, SD = 0.43), $t(20) = 5.51$, $p = 0.00$*, $p \leq 0.05$.

Table 3: *Results on Gender's Sense Making and Effort for Both Schools in Total*

Gender	Likert Scale Value	Wilcoxon Signed Ranks Test		Paired Samples t-test	
		Pre-survey	Post-survey	Pre-survey	Post-survey
Male (N=17)	Mean			3.89	4.36
	SD			0.32	0.31
	Median	3.86	4.29		
	Z/ t value	Z = -3.52		t(16) = 7.88	
	p – value	0.00*		0.00*	
Female (N=21)	Mean			3.81	4.18
	SD			0.43	0.42
	Median	3.86	4.29		
	Z/ t value	Z = -3.70		t(20) = 5.51	
	p – value	0.00*		0.00*	

**is significant at $p \leq 0.05$*

These findings are not in line which encountered by Vaz, Quinn, Heinricher & Rissmiller (2013), who done their study about the long – term impacts of PBL on engineering majors showed that female students indicated were impacted more with PBL compared to male students which female students have higher response in integrating information from multiple sources, develop ideas, deliver effective presentations and develop a solid base of knowledge. According to Lamoureux, Behesti, Cole, Abuhimed & AlGhamdi (2013), who done a research about inquiry – based learning project showed that female students seem to be more optimistic, less frustrated, more confident and satisfied with their experiences in comparison with the male students. Moreover, female students have higher sense making and efforts towards the implementation of PBL which during PBL female students were overwhelmed, gained a lot of experience, felt challenging and have problem with time management (Zastavker, Ong & Page, 2006).

Urban and Rural Students' Sense Making and Effort towards Physics

Wilcoxon signed-ranks test results from Table 4 showed that urban students have a statistically significant difference between the median value Likert scale degree of agreement for post-survey and pre-survey (Z = -3.74, p = 0.00*). The median value was 4.21 and pre-survey was 3.71. Meanwhile, for rural students have a statistically significant difference between the median value Likert Scale degree of agreement for post-survey and pre-survey (Z = -3.45, p = 0.00*). The median value for post-survey was 4.36 and pre-survey was 4.07.

Paired samples *t*-test results from Table 4 showed urban students have a statistically significant difference between the mean value level Likert scale degree of agreement of post-survey (M = 4.21, SD = 0.37) and pre-survey (M = 3.74, SD = 0.37) that the students have, t (19) = 8.06, p = 0.00*, $p \leq 0.05$. Rural students revealed have a statistically significant difference in mean value level Likert Scale degree of agreement of post-survey (M = 4.33, SD = 0.39) and pre-survey (M = 3.96, SD = 0.38) that the students have, t (17) = 4.98, p = 0.00*, $p \leq 0.05$.

Table 4: *Results on Urban and Rural Students' Sense Making and Effort*

Students	Likert Scale Value	Wilcoxon Signed Ranks Test		Paired Samples t-test	
		Pre-survey	Post-survey	Pre-survey	Post-survey
Urban (N=20) School A	Mean			3.74	4.21
	SD			0.37	0.37
	Median	3.71	4.21		
	Z/ t value	Z = -3.74		t(19) = 8.06	
	p – value	0.00*		0.00*	
Rural (N=18) School B	Mean			3.96	4.33
	SD			0.38	0.39
	Median	4.07	4.36		
	Z/ t value	Z = -3.45		t(17) = 4.98	
	p – value	0.00*		0.00*	

**is significant at $p \leq 0.05$*

These findings are in line with Agbaje & Awodun (2014) stated that urban students have higher achievement in academic performance compared to rural students towards science subject which urban students were more encouraging than the rural students. In addition, findings in this study are contradicted with Freeman & Anderman (2005) which rural students have higher increase in personal mastery goals (i.e., purpose, belief, belief and commitment) as compared to urban students. Similar findings are encountered by Han, Yalvac, Capraro & Capraro (2015), stated that from Science, Technology, Engineering and Mathematics (STEM) PBL, helped individual to create things, think, understand and connect STEM concepts with one another. In addition, similar

findings are encountered by North Daviess School Corporation, Indiana, USA & Education Networks of America (2008), about the impact of PBL – high tech program towards rural school which this program made the students to think and have understanding more about computing and technology.

Conclusion

The Colorado Learning Attitude about Science Survey (CLASS) – sense making and effort Category results have reflected a strong agreement that implementation of Project-Based Learning (PBL) can increase students' sense making and effort to learn physics. Projects came out with the questions that sometimes cannot be solved by rote learning as students engage in an active role. Moreover, projects have served to bridge classroom learning with the real-life applications. Through PBL, students have a clear understanding with the physics concepts they learned in class and indirectly can change their perception towards physics into more positive one and able to connect physics concepts into real life situations.

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