PHYSICS ACHIEVEMENT IN STEM PROJECT BASED LEARNING (PjBL): A GENDER STUDY

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Abstract: Today's learners will face increasing global competition for college entrance and jobs after graduation. They need to succeed in work, life and citizenship, as well as skills that are necessary for 21st century. Teaching and learning's in the 21st century has to put the emphasis on the 4Cs, collaboration, critical thinking, creativity, and communication in the gender equality environments. Science, Technology, Engineering, and Math (STEM) Project Based Learning (PjBL) provides students to learn 4Cs skills. However, the role of gender in STEM PjBL is not clear well. So, this experimental study, run a project within an experimental group of 50 students and compare with another 57 students in the control group by employing Mixed-Design ANOVA, to evaluate changes in achievement performance differences between the genders? We observe there were not significant differences in performance of girls and boys in the high school by running a project and measuring students' achievement. Future study should cover the effect of gender differences on the STEM PjBL teaching method in the high school for preparing students for 21st century challenges in a broad range.

Keywords: 21st century skills, enhance teaching and learning, gender differences, physics education, achievements

INTRODUCTION

The goal of teaching and learning for 21st century is to find effective teaching methods and create a curriculum according to the 21st century requirements (Holubova, 2008). In the last few decades, many reform initiatives have shaped teaching and learning in science, technology, engineering and mathematics (STEM) disciplines (Asghar, Ellington, Rice, Johnson, & Prime, 2012). These reform efforts include a shift from teaching students to remember and execute isolated facts and skills, to having students experience learning as scientists, engineers and mathematicians do (Asghar et al., 2012; National Council of Teachers of Mathematics, 2000). Reform efforts within each of the STEM disciplines have focused on such strategies as inquiry learning (Minstrell & van Zee, 2000), project-based learning (Swartz, Costa, Beyer, Reagan, & Kallick, 2007), constructivist learning (Mayer, 2004), problem-based learning and the integration of technology across all STEM disciplines (Asghar et al., 2012). Project Based Learning (PjBL) must be at the center of 21st century instruction, if we are serious about reaching educational goals (Clark, 2014; Larmer & Mergendoller, 2010).

STEM is particularly suited for PjBL because of the natural overlap between the fields of science, technology, engineering and mathematics (Capraro & Jones, 2013). So, STEM and project-based learning is match together. STEM PjBL is an interdisciplinary instructional approach utilising a project. In STEM PjBL, students apply abstract concepts of science and mathematics to an engineering context using technology tools. Students have the opportunity to communicate and collaborate with peers and teachers in small groups while exploring a project (Cheng, Lam, & Chan, 2008). These opportunities stimulate students to construct their own knowledge and make use of formative feedback that is important in the STEM PjBL lessons (Han, 2013). STEM PjBL engage students in solving problems within a project individually and in groups while they explore strategies and apply content knowledge to real-world tasks (Barron et al., 1998). Through a project composed of several problems, students can apply their knowledge learned before or at present to finding strategies to solve new problems or new contexts, recognize their meaning in their lives, and gain a deep understanding of the subjects. Moreover, because STEM PjBL consist of diverse hands-on activities, communications, and collaboration with peers, it helps students develop positive self-beliefs regarding their ability to sole physics problems (Han, 2013). Rigorous projects help students learn key academic content and practice 21st century skills such as collaboration, communication & critical thinking (U.S. Department of Education, 2015). All the STEM PjBL features including the 4Cs, collaboration, critical thinking, creativity, and communication are necessary for the 21st century in the gender equality environments.

Few study tried to investigate gender effect in physics test (Sawtelle, 2011). Hampton and Mason (2003) investigated learning disabilities, gender, sources of efficacy, self-efficacy beliefs, and academic achievement in high school students. Sawtelle (2011) did a gender study investigation in students self-efficacy in physics test. Various studies were measured students' achievement scores who participated in the STEM PjBL (Baran & Maskan, 2010; Doppelt, 2003; Hong, Chen, & Hwang, 2013). However, very limited studies focused on the effect of gender on physics problems solving (learning achievement) in the high school (Jamali, Nurulazam Md Zain, Samsudin, & Ale Ebrahim, 2015). In this study we will measure the effect of gender on gaining achievements in the physics mechanics test while, using either STEM PjBL or conventional teaching methods.

METHODOLOGY

The objective of this study was to find gender effect on students' achievement performance. The statistical package social sciences (SPSS) version 20 used for Mixed-Design (Split-Plot) ANOVA with Pre and Post-test achievement as within-subjects factor, and between-subjects factors which were Groups (experimental and control) and gender (male and female). The Mixed-Design (Split-Plot) ANOVA was conducted to assess whether there were differences in students' average achievement scores in terms of their gender and teaching methods (conventional and STEM PjBL) conditions. The Greenhouse-Geisser correction was applied where appropriate.

A total of 107 high school students from two different groups, 50 students from experimental group, and 57 students from control group participated in this study. The control group consists of 22 females and 28 males, while, the experimental group consists of 21 females and 36 males. The control group received conventional teaching method, while, the experimental group received STEM PjBL method to learn physics mechanics. The experimental group runs two projects to learn physics principles behind the projects. Students in all groups learned from their respective teaching methods. Both groups answered 10 physics mechanics questions (Pre-Test) prior to start teaching based on conventional or STEM PjBL methods. The pre-test conducted to make sure that there is not any differences between two groups initial knowledge about physics mechanic. After the interventions again both groups attended in a final achievement test (Post-Test). In the post-test, all the participants were asked to answer 10 physics mechanics questions related to pulley system and pendulum (the same questions as pre-test) individually on paper to measure their knowledge after intervention.

RESULTS AND DISCUSSIONS

Classroom average achievement scores of students physic mechanic tests for experimental and control groups, and gender are presented in Table 1.

Figure 1 shows Changes in the students' achievement scores with respect to groups (experimental and control) and different gender (male and female).

Table 1. Classroom average achievement scores (Maximum possible score is 20.00)

Experimental and control groups	Gender	*N*	Test	Mean (SD)
EXP	Female	22	Pre-Test	5.73 (2.33)
			Post-Test	14.36 (2.44)
	Male	28	Pre-Test	5.64 (2.44)
			Post-Test	14.64 (2.38)
CONT	Female	21	Pre-Test	6.38 (2.58)
			Post-Test	8.76 (2.57)
	Male	36	Pre-Test	6.00 (2.57)
			Post-Test	9.78 (3.23)

Notes: EXP = Experimental group; CONT = control group

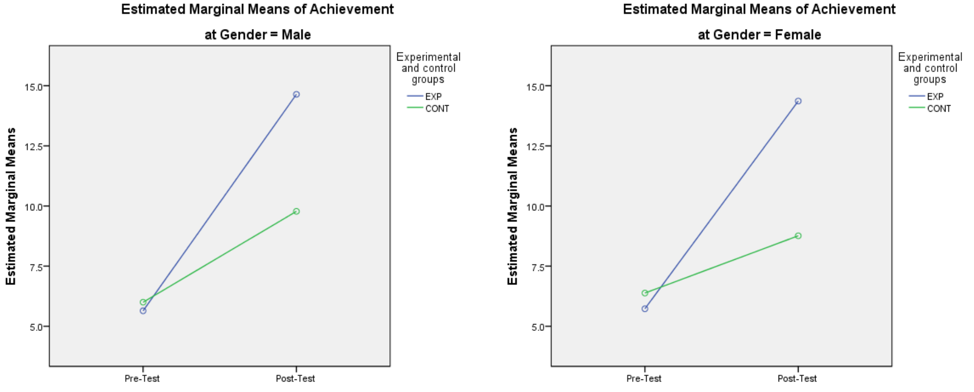

Figure 1. Changes in the students' achievement scores with respect to groups (experimental and control) and gender (male and female)

Table 2 shows Mixed-Design (Split-Plot) ANOVA results of pre and post achievement as within-subjects factor and Groups (experimental and control) and gender (male and female) as between-subjects factors. Results from Table 2 shows that the learning achievement gain is higher in experimental group compare to control group (Greenhouse-Geisser corrected F (1, 103) = 362.96, partial $\eta^2 = 0.78$, $p < 0.001$). Therefore, students who used STEM PjBL method to solve physics mechanic problems gained more achievement than the students who used conventional teaching method. While the effect of gender is not statistically significant either in interaction with pre- and post-test achievement (Greenhouse-Geisser corrected F (1, 103) = 1.99, partial $\eta^2 = 0.02$, $p = 0.16$) or pre and post-test achievement × experimental and control groups × gender (Greenhouse-Geisser corrected F (1, 103) = 0.68, partial $\eta^2 = 0.01$, $p = 0.41$). Hence, there are not significant differences in performance of girls and boys in the high school by running a STEM PjBL method and measuring students' physics mechanics achievement. In summary, the main effect of STEM PjBL teaching method is significant while, the interaction of gender is not significant.

Table 2. Mixed-Design (Split-Plot) ANOVA results of pre- and post-achievement

Source	Type III sum of squares	df	MS	F value	P value	η^2
Pre_Post	1808.21	1	1808.21	362.96	0.00	0.78
Pre_Post * GRP	420.71	1	420.71	84.45	0.00	0.45
Pre_Post * Gender	9.90	1	9.90	1.99	0.16	0.02
Pre_Post * GRP * Gender	3.41	1	3.41	0.68	0.41	0.01
Error (Pre_Post)	513.13	103	4.98			

η^2 = Partial Eta Squared,
MS = Mean Square

The results of this study revealed that using STEM PjBL enhances the students' ability to achieve belter scores in comparison of their peers with the conventional teaching method. The post-test means scores of students' achievements on solving ten physics mechanics problems who follow STEM PjBL showed superior problem solving ability. Various studies were reported improvement of students' achievement scores who participated in the STEM PjBL (Baran & Maskan, 2010; Doppelt, 2003; Hong et al., 2013). However, very limited studies tried to investigate gender effect in physics test (Sawtelle, 2011). The finding of the current research is consistent with the previous studies results. Han (2013) found that students improve their academic achievement through STEM PjBL activities. Most studies generally verified the effectiveness of STEM PjBL on students' achievement (Han, Capraro, & Capraro, 2014; Han, 2013; Hmelo-Silver, 2004; Schauble, Glaser, Duschl, Schulze, & John, 1995). Weinburgh (1995) in a meta-analysis which covering the literature between 1970 and 1991, stated that boys have more positive attitudes toward science than girls. However, this research shows that nowadays in the STEM PjBL environments boys and girls are achieve equally the physics science scores. Furthermore, the teaching method was narrowed the physics achievement gap between boys and girls (Lawrenz, Wood, Kirchhoff, Kim, & Eisenkraft, 2009). Else-Quest, Mineo, and Higgins (2013) indicated that, "regarding STEM achievement at the intersection of gender and ethnicity, data have generally pointed to a pattern in which gender differences in math and science achievement are largest among White and Latino/Latina samples and smallest among Asian American and African American samples." Hence, future research should consider the gender and ethnicity together for measuring physics achievement in STEM project based learning.

CONCLUSION

This study confirmed that STEM PjBL can better foster students' problem solving skill to reach higher level of achievements in physics mechanic test. There were not any differences in performance of girls and boys in the high school by running a STEM PjBL teaching method and measuring students' achievement in physics mechanic test in high school. The policy makers and educators need to provide a gender equality environment and take a lead to implement STEM PjBL which is necessary for the 21st century leaning designs. Although this research obtained a statistically significant difference in the students' achievement in physics mechanic test scores before and after the intervention, and non-significant difference in the students' gender to get the same results. We cannot say the intervention caused the improvement with 100% certainty. There are many other factors (research limitations) that should be consider for future research such as students', parents background, parents educations, number of siblings, and ethnicity.

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