



**HAL**  
open science

## Physics Achievement in STEM PjBL: A Gender Study

Mohd Ali Samsudin, Ahmad Nurulazam Md Zain, Seyedh Mahboobeh Jamali,  
Nader Ale Ebrahim

► **To cite this version:**

Mohd Ali Samsudin, Ahmad Nurulazam Md Zain, Seyedh Mahboobeh Jamali, Nader Ale Ebrahim. Physics Achievement in STEM PjBL: A Gender Study. *The Asia Pacific Journal of Educators and Education*, 2018, 32, pp.21-28. hal-02105683

**HAL Id: hal-02105683**

**<https://hal.science/hal-02105683>**

Submitted on 21 Apr 2019

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - ShareAlike 4.0 International License

## **Physics Achievement in STEM PjBL: A Gender Study**

Mohd Ali Samsudin<sup>a</sup>, Ahmad Nurulazam Md Zain<sup>a</sup>, Seyedh Mahboobeh Jamali<sup>\*a</sup>,  
and Nader Ale Ebrahim<sup>b</sup>

<sup>a</sup>*School of Educational Studies (PPIP), Universiti Sains Malaysia, Penang, Malaysia*

<sup>b</sup>*Centre for Research Services, IPPP, University of Malaya, Malaysia*

*\*Corresponding author: Email: Mahjamali@Gmail.com*

### **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 21<sup>st</sup> century. Teaching and learning's in the 21<sup>st</sup> 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 21<sup>st</sup> century challenges in a broad range.

### **Keywords**

21<sup>st</sup> century skills, Enhance teaching and learning, Gender differences, Physics education, Achievements

### **INTRODUCTION**

The goal of teaching and learning for 21<sup>st</sup> century is to find effective teaching methods and create a curriculum according to the 21<sup>st</sup> 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; NCTM, 2000). Reform efforts within each of the STEM disciplines have focused on such strategies as inquiry learning (Minstrell, 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 21<sup>st</sup> 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 utilizing 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 solve physics problems (Han, 2013). Rigorous projects help students learn key academic content and practice 21<sup>st</sup> 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 21<sup>st</sup> 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)

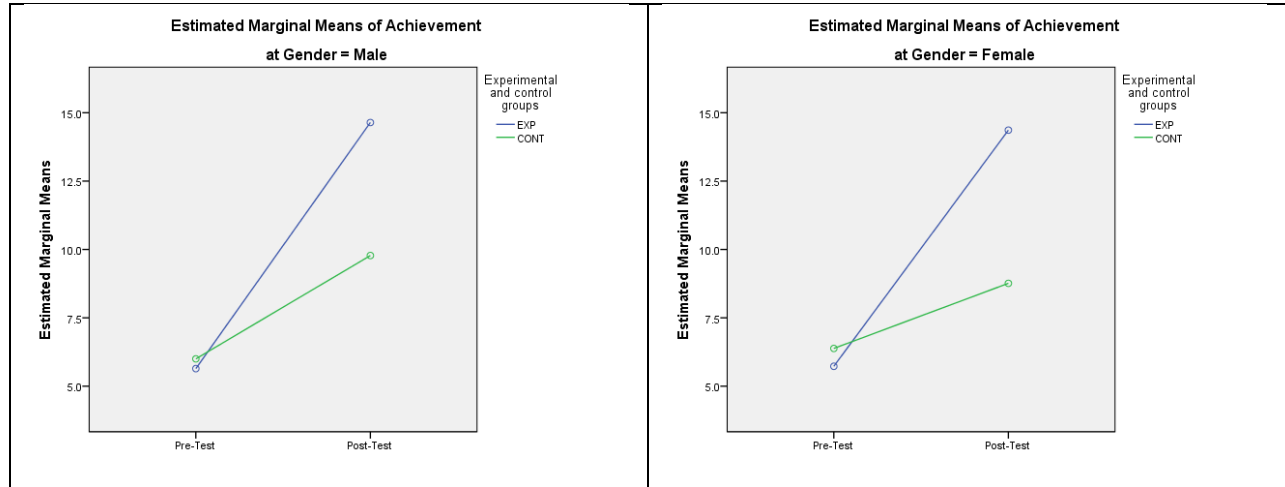


Figure 1 Changes in the students' achievement scores with respect to groups (experimental and control) and gender (male and female)

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  $\times$  experimental and control groups  $\times$  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	$\eta^2$
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			

$\eta^2$  = Partial Eta Squared, MS = Mean Square

The results of this study revealed that using STEM PjBL enhances the students' ability to achieve better 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 21<sup>st</sup> 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.

## REFERENCES

- Asghar, A., Ellington, R., Rice, E., Johnson, F., & Prime, G. M. (2012). Supporting STEM education in secondary science contexts. *Interdisciplinary Journal of Problem-based Learning*, 6(2), 4.
- Baran, M., & Maskan, A. (2010). The effect of project-based learning on pre-service physics teachers electrostatic achievements. *Cypriot Journal of Educational Sciences*, 5(4), 243-257.
- Barron, B. J., Schwartz, D. L., Vye, N. J., Moore, A., Petrosino, A., Zech, L., et al. (1998). Doing with Understanding: Lessons From Research on Problem-and Project-Based Learning. *Journal of the Learning Sciences*, 7, 271-311.
- Capraro, M. M., & Jones, M. (2013). Interdisciplinary STEM project-based learning *STEM Project-Based Learning* (pp. 51-58): Springer.
- Cheng, R. W. Y., Lam, S. F., & Chan, J. C. Y. (2008). When high achievers and low achievers work in the same group: The roles of group heterogeneity and processes in project-based learning. [Article]. *British Journal of Educational Psychology*, 78, 205-221.
- Clark, C. J. (2014). *Self and Collective Efficacy Perceptions during Project-Based Learning Implementation*. Ashland University, Ashland, OH, USA.
- Doppelt, Y. (2003). Implementation and assessment of project-based learning in a flexible environment. *International Journal of Technology and Design Education*, 13(3), 255-272.
- Else-Quest, N. M., Mineo, C. C., & Higgins, A. (2013). Math and Science Attitudes and Achievement at the Intersection of Gender and Ethnicity. [Article]. *Psychology of Women Quarterly*, 37(3), 293-309.
- Hampton, N. Z., & Mason, E. (2003). Learning Disabilities, Gender, Sources of Efficacy, Self-Efficacy Beliefs, and Academic Achievement in High School Students. *Journal of School Psychology*, 41(2), 101-112.
- Han, S., Capraro, R., & Capraro, M. M. (2014). How Science, Technology, Engineering, and Mathematics (Stem) Project-Based Learning (PBL) Affects High, Middle, And Low Achievers Differently: The Impact of Student Factors on Achievement. *International Journal of Science and Mathematics Education*, 1-25.
- Han, S. Y. (2013). *The Impact of STEM PBL Teacher Professional Development on Student Mathematics Achievement in High Schools*. Texas A&M University.
- Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational psychology review*, 16(3), 235-266.

Cite as: Samsudin, M. A., Nurulazam Md Zain, A., Jamali, S. M., & Ale Ebrahim, N. (2017). Physics Achievement in STEM PjBL: A Gender Study. *The Asia Pacific Journal of Educators and Education*, 32.

Holubova, R. (2008). Effective Teaching Methods--Project-based Learning in Physics. *Online Submission*, 5(12), 27-36.

Hong, J. C., Chen, M. Y., & Hwang, M. Y. (2013). Vitalizing creative learning in science and technology through an extracurricular club: A perspective based on activity theory. [Article]. *Thinking Skills and Creativity*, 8, 45-55.

Jamali, S. M., Nurulazam Md Zain, A., Samsudin, M. A., & Ale Ebrahim, N. (2015). Publication Trends in Physics Education: A Bibliometric study. *Journal of Educational Research*, 35, 19-36.

Larmer, J., & Mergendoller, J. R. (2010). *The main course, not dessert, How Are Students Reaching 21st Century Goals? With 21st Century Project Based Learning*. Novato, CA: Buck Institute for Education.

Lawrenz, F., Wood, N. B., Kirchhoff, A., Kim, N. K., & Eisenkraft, A. (2009). Variables affecting physics achievement. *Journal of Research in Science Teaching*, 46(9), 961-976.

Mayer, R. E. (2004). Should There Be a Three-Strikes Rule against Pure Discovery Learning? *American Psychologist*, 59(1), 14-19.

Minstrell, J., & van Zee, E. (2000). *Inquiring into Inquiry Learning and Teaching in Science* (24 Mar 2016 ed.). Washington, DC: American Association for the Advancement of Science.

NCTM. (2000). *Principles and standards for school mathematics* (Vol. 1). Reston, VA: National Council of Teachers of Mathematics.

Sawtelle, V. (2011). *A gender study investigating physics self-efficacy*. Florida International University, ProQuest LLC, Ann Arbor, MI.

Schauble, L., Glaser, R., Duschl, R. A., Schulze, S., & John, J. (1995). Students' understanding of the objectives and procedures of experimentation in the science classroom. [Article]. *Journal of the Learning Sciences*, 4(2), 131-166.

Swartz, R. J., Costa, A. L., Beyer, B. K., Reagan, R., & Kallick, B. (2007 ). *Thinking based learning*. Norwood, MA: Christopher-Gordon.

U.S. Department of Education. (2015). Project Based Learning at Harmony Public Schools. *District Reform Support Network* 1-11.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching*, 32(4), 387-398.