Procedural Checkpoint-Infused Laboratory Activity: Impact on the Attitude Towards Physics Among STEM Students With Varying Academic Achievement

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The Asian Conference on Education & International Development 2023
Official Conference Proceedings

Abstract
As learners are now back in the classroom since the COVID-19 pandemic outbreak, it was observed that there is a growing negative attitude towards physics among the grade 12 STEM students. Self-assessment was used as a basis to enhance hands-on laboratory activities by infusing procedural checkpoint questions in laboratory worksheets that will elicit students' active participation during the activity. The researcher determined the impact of enhanced laboratory activities on the attitudes towards physics of students with different academic achievements. Groups of high achieving and low achieving students were exposed to laboratory activities based on traditional (TLA) and enhanced (PCILA) structure. Four factors of attitude towards physics course were measured using the Physics Course Attitude Scale (PCAS) by Cermik and Kara (2020), specifically the students' F1) interest F2) unwillingness F3) academic self and F4) necessity. Two-way ANOVA was used to determine the interaction of the factors on the attitude toward the physics course. Data reveals that among the factors of attitude, only interest is influenced by academic achievement of the learners and that neither academic achievement nor laboratory activities can be a predictor of students' attitude toward physics. Furthermore, the interaction of academic achievement and type of laboratory activity doesn't significantly change students' attitude toward physics course.

Keywords: Attitude, Physics, Achievement

Introduction

Science education is an integral part of students' primary and secondary education. Among the science courses which appears problematic learners is Physics. Studies have revealed that most high school students perceive introductory physics as difficult particularly the application of knowledge into real-life and problem solving (Nava & Camarao, 2017). Apart from the cognitive requirement of the course, the transition to distance learning due to COVID in the last two years have contributed to students' negative view on physics. Some problems that contributed to such negative view are technical problems i.e., inter-connection, lack or resources at home, limited communication between teachers and classmates, and the reduced experimental activities (Stefanidou, 2022). As learners are now back in the classroom it was observed that there is a negative attitude towards physics among the grade 12 STEM students.

Students' Attitude towards Physics and their Achievement in the Course

The negative attitude of students towards Physics among grade 12 students poses a concern in their achievement in Physics. A key factor in the realm of learning has been found to affect students' achievement in science, one of which is the attitude towards the subject. The relationship of students' attitude towards science and achievement has been widely explored over the years. Correlational studies show that the attitude toward science of students in the secondary level has a significant relationship with their achievement in subject (Wilson, 1983; Shabbir Ali & Awan, 2013; Mao et. al., 2021). Research have cited that there is significant relationship between students' attitude and achievement in Physics. It implies that students with positive attitude towards physics are more likely to achieve in the subject. Thus, students' attitude can be a predictor of achievement in physics (Martinko & Vorkapić, 2017). It has also been recently found that the attitudes of students towards Physics is a crucial requirement for students who are new to learning Physics in order to continue and enhance the learning process (Hernanez-Suarez, et. al, 2022).

Laboratory Activities and Students' Attitude Towards Physics

Several pedagogical approaches have been developed in order to increase students' interest in Physics and one of which is the integration of hands-on laboratory experiments. Organ-Bekiroglu (2017) found that provision of technology supported and laboratory-based instructions to students leads to an increase in positive attitude toward physics. The study also showed that the impact on students' attitudes towards Physics is not significantly different than the impact of technology-based instructions. Furthermore, integrating technology and laboratory experiments such as virtual laboratory can enhance students' problem solving, critical thinking, creativity, conceptual understanding, science process skills, lab skills, motivation, interest, perception, and learning outcomes (Firman & Iwarto, 2017).

A substantial amount of research show that the use of nontechnology-based laboratory activities in Physics courses has a significant impact on the attitude of students in science. The integration of hands-on laboratory programs and instructions can positively improve the attitude of students towards science (Freedman, 1997; Adesoji & Raimi, 2004).

However, recent studies prove otherwise. Hands-on experiments do not significantly affect students' interest and perceived usefulness of the experiment. And that most students feel that more effort is needed in laboratory activities (Snetinova, et. al., 2018). Applying real and virtual laboratory activities does not directly affect students learning outcomes neither can the achievement motivation be a predictor of student's learning outcomes (Ernita, et. al., 2021). These recent developments pose a question whether enhancing hands-on laboratory activities can still be utilized to enhance students' attitude toward science.

Procedural Questions as Self-Assessments on Students' Motivation and Attitude

Mcmillan & Hearn (2008) found in their study that greater student involved in the self-assessment process, that is involvement in reflection and monitoring of learning and thinking, results to greater student motivation by providing a greater sense of ownership and responsibility. There is also a strong correlation between self-assessment and motivation among learners (Prataman, 2018). Furthermore, as self-assessment has been proven to positively affect students' academic skills, it is also a strong chance of increasing secondary students' academic intrinsic motivation for self-assessment enables students to critically assess their work and provides them skills that they may utilize for their academic future (Bengston, 2020).

Some studies revealed that students' attitude towards physics subjects and motivation are interconnected such that there is a unidirectional relationship between motivation and attitude. If students' motivation rises, then the attitude rise, and if the motivation drops then the attitude drops as well (Astalini, et. al., 2019). In the Philippine context, the same relationship between motivation and attitude were found (Guido, 2020). Since the motivation and self-assessments may influence students' attitudes then, such connection may be implored to enhance hands-on experiments in order to be a tool to scaffold students' attitudes toward science.

Research Questions

Self-assessment will be used as a basis to enhance hands-on laboratory activities by infusing checkpoint questions in the worksheets that will elicit students' active participation during the activity. The researcher wants to determine if enhanced laboratory activities have an impact on the attitudes towards physics of students with different academic achievements. Specifically, the researcher wanted to know (a) if the infusing checkpoint questions in the laboratory activities will influence the attitude of the students toward the physics course (b) does the academic achievement of students influence their attitude toward the physics course (c) is there a significant interaction between students' achievement and the type of laboratory activity and whether they could influence the attitude of students toward physics.

Hypothesis 1: There is no significant difference between the students who answered the checkpoint infused laboratory activity in relation to their attitude toward physics course.

Hypothesis 2: There is no significant difference between the students with high achievement and low achievement in their attitude toward the physics course in terms of the following factors: a) their interest towards the subject; b) unwillingness to learn the subject; c) academic perspective of themselves in the subject; d) necessity to learn the subject.

Hypothesis 3: There is no significant interaction between the type of laboratory activity taken by students and their achievement level in relation to their attitude towards the physics course.

Methods

Sample

This study examined 48 grade 12 students under the age of 17 to 18 years of age and are enrolled in the Science, Technology, Engineering, and Mathematics (STEM). The participants were from the Biomedical and Information, Communication, & Technology specializations who are taking the General Physics 1 course in their first semester. Four sections from the said specializations were used with participants consisting of 19 males and 29 females. The said number of participants were grouped according to their academic achievement in their physics course. The academic achievement in physics of the students were determined using their midterm grade in the course. Only the students with extreme scores, the students with the highest and lowest marks, were allowed to participate in the study. A parent/guardian consent form was also provided to the participants before participating in the study.

Table 1. ***Descriptive statistics of the Achievement Level of Participants***

	No. of Students	Percent
High Achievement	24	50.0
Low Achievement	24	50.0
Total	48	100.0
Male	19	39.6
Female	29	60.4
Total	48	100.0

Measures

Four factors in the attitudes towards physics were measured, which are 1) Interest, 2) Unwillingness, 3) Academic self, and 4) Necessity using the Physics Course Attitude Scale (PCAS) by Cermik and Kara (2020). The survey is a Likert Scale with positive and negative statements about the four factors of attitude specifically, interest (n = 4), unwillingness (n = 6), academic self (n = 5), and necessity (n = 5). The students' achievement levels were also determined using their midterm grades in their physics course which is a numerical report of their performance in the subject. Their academic achievement level in their physics course was used in determining the groups in the study.

Procedures

The researcher designed an enhanced laboratory activity with checkpoint questions that would serve as students' self-assessment as they are conducting the activity. The traditional laboratory activity had the usual parts pf a laboratory activity such as (a) objectives, (b) introduction, (c) procedure, (d) data and results, (e) analysis and (f) guide questions while the enhance laboratory activity were infused with checkpoint questions that would enable students to become more involved in the activity. The enhanced laboratory activity was called Procedural Checkpoint Infused Laboratory Activity (PCILA). Sample procedural questions and their corresponding domains are shown in Table 2. These procedural questions infused in the laboratory activity were validated by group of professional physics teachers before the deployment of the enhanced laboratory activity.

Table 2. ***Sample Procedural Checkpoint Questions and Laboratory Domains***

Domains	Question
Active Reflection	*Checkpoint 1:* *Which part of the procedure is difficult to conduct and how do you think this step would affect the data in the experiment?*
Pre-Data Analysis	*Checkpoint 2:* *Based on the current trend of the data gathered, what are the independent and dependent variables?*
Troubleshooting	*Checkpoint 3:* *What are the percent errors/percent differences of your data and the actual data? What do you think contributed to these errors?*
Extension	*Checkpoint 4:* *How would the procedures change if the equation for the acceleration due to gravity is modified into* $$g = \frac{a(m_1 + m_2)}{m_2 - m_1}$$ *instead of the initial* $$g = \frac{a(m_1 + m_2)}{m_1 - m_2}$$

The participating sections were grouped into four according to their achievement levels on the basis of their midterm grades. Each groups had equal number of high and low achieving students. Two groups were given the Procedural Checkpoint Infused Laboratory Activities (PCILA) and two groups received the Traditional Laboratory Activity (TLA). After the activity, the students answered the Physics Course Attitude Scale in the next session. Each response in the survey were sorted by factor. The hypotheses were tested by analyzing the gathered data using the Analysis of Variance (Two-Factorial) without repeated measures.

Table 3. ***Groupings Formed in the Study***

Groups	PCILA	TLA
High Academic Achievement Level	G-I	G-II
Low Academic Achievement Level	G-III	G-IV

Note: Procedural Checkpoint-infused Laboratory Activity (PCILA) & Traditional Laboratory Activity (TLA)

Due to the limited sample size in the study, the Shapiro-Wilk test and Levene's test of homogeneity were done to determine the normality and variability of the sample data. The preceding tables in the results present the normality and variability of the data as well as show how both the motivation groups and laboratory groups are normally distributed with p values greater than 0.05 in all factors of students' attitude towards physics tested. Furthermore, results of the Levene's Test in each of the four factors of attitude toward physics specified in the PCAS reveal that variances are equal across each group. With such results, the researcher then proceeded with using a parametric test in testing the hypotheses. The hypotheses were tested by utilizing the Analysis of Variance (Two-Factorial) without repeated measures since the effect of two variables, achievement in physics and laboratory activities based on traditional and enhanced laboratory activity structure, were tested and that no pre and post assessments were done in the study.

Results

The researchers tested the influence of two independent variables, students' academic achievement level and the laboratory activity based on the traditional and enhanced checkpoint-infused laboratory activity structure, on the dependent variable, attitude towards physics of students using the Two-way Analysis of Variance (with no repeated measures). The statistical tool proved to be efficient in determining if each of the independent variables have a significant interaction with the dependent variable and if the interaction of the independent variables can significantly influence the dependent variable.

The interaction of the independent variables was tested on the four factors of attitude toward physics specifically, F1) Interest, F2) Unwillingness, F3) Academic Self, and F4) Necessity.

Interest (F1)

The Shapiro-Wilk test and Levene's Test in Table 4 and Table 5, respectively show that the data gathered from the sample are normally distributed and that there are equal variances across each group. These are enough to satisfy the assumptions for a parametric test to test the hypothesis.

Table 4. ***Shapiro-Wilk Test of Normality (F1)***

		Shapiro-Wilk		
Factor	Motivation	Statistic	df	Sig.
Interest (F1)	High	.967	24	.605
	Low	.830	24	.001
	Lab Activity	Statistic	df	Sig.
Interest (F1)	PCILA	.885	24	.010
	TLA	.945	24	.207

*p < .05

Table 5. ***Levene's Test of Equality of Error Variance (F1)***

F	df1	df2	Sig.
1.008	3	44	.398

Note: Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Table 6. ***Analysis of Variance Between Effects of Academic Achievement and Type of Lab Activity on Interest (F1)***

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5.796[a]	3	1.932	2.774	.052	.159
Intercept	457.876	1	457.876	657.511	.000	.937
Achievement Category	3.126	1	3.126	4.489	.040	.093
Type of Lab Activity	1.980	1	1.980	2.844	.099	.061
Achievement Category * Type of Lab Activity	.689	1	.689	.989	.325	.022
Error	30.641	44	.696			
Total	494.313	48				
Corrected Total	36.436	47				

Note: At 95% confidence intervals

The results for ANOVA (Two-Factorial) as shown in Table 6 present that the *p* value for academic achievement is less than .05 which indicates that the interest of students in physics is influenced by their academic achievement in their physics course. This means that students' performance in physics as measured from their numerical grades may influence interest to learn physics. Such result agrees with the results found in some earlier studies about the positive correlation between attitude and academic achievement of students (Wilson, 1983; Shabbir Ali & Awan, 2013; Mao et. al., 2021; Martinko & Vorkapić 2017). In contrary to the results for academic achievement factor, it can be gleamed from Table 6 that the type of laboratory activity factor has a $p = .099$ which indicates that the said factor has no significant influence on students' interest to learn physics. The type of laboratory activity taken by the students whether based on traditional or enhanced structure does not influence the attitude of the students in terms of the interest factor.

The interaction of the academic achievement factor and type of laboratory activity doesn't influence students' interest as indicated by the value $p > .05$. This means that the interaction of two factors is independent of students' interest to learn physics.

Though the *p* value for the interaction of the independent factors was not statistically significant, the interaction of the factors as shown in Figure 1 reveals that the group who took the PCILA had higher averages in F1 than the group that took the TLA. However, there is a large gap between the averages of the high and low achieving students who took the PCILA. This indicates that the academic achievement of the students may affect their interest (F1) averages.

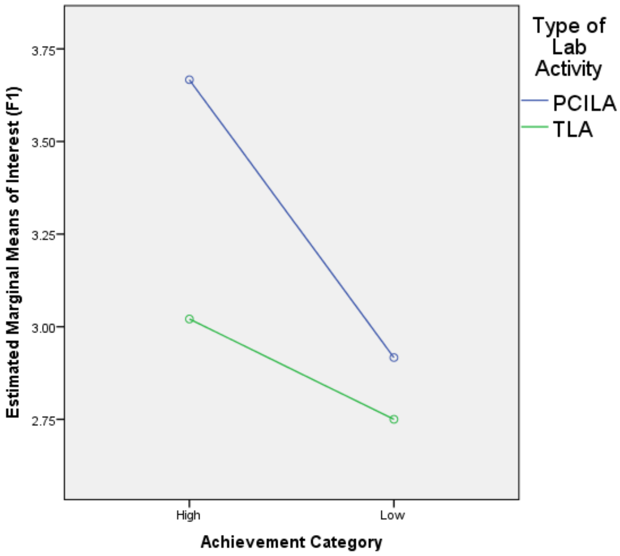

Figure 1. ***Academic Achievement and Type of Lab Activity Interaction***

Note: Procedural Checkpoint-infused Laboratory Activity (PCILA) & Traditional Laboratory Activity (TLA)

Unwillingness (F2)

The test of normality and homogeneity of the data as shown in Table 7 and Table 8, respectively, shows that the gathered data are normally distributed and have equal variances across each group. Thus, the assumptions for the parametric test that was utilized are satisfied.

Table 7. ***Shapiro-Wilk Test of Normality (F2)***

Factor	Motivation	Shapiro-Wilk Statistic	df	Sig.
Unwillingness (F2)	High	.947	24	.236
	Low	.964	24	.528
	Lab Activity	Statistic	df	Sig.
Unwillingness (F2)	PCILA	.963	24	.495
	TLA	.985	24	.967

*p < .05

Table 8. ***Levene's Test of Equality of Error Variances (F2)***

F	df1	df2	Sig.
.656	3	44	.584

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups

Table 9. ***Analysis of Variance Between Effects of Academic Achievement and Type of Lab Activity on Unwillingness (F2)***

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.718[a]	3	.906	1.408	.253	.088
Intercept	348.481	1	348.481	541.791	.000	.925
Achievement Category	1.687	1	1.687	2.624	.112	.056
Type of Lab Activity	1.021	1	1.021	1.587	.214	.035
Achievement Category * Type of Lab Activity	.009	1	.009	.014	.905	.000
Error	28.301	44	.643			
Total	379.500	48				
Corrected Total	31.019	47				

Note: at 95% confidence interval

Table 9 reveals that the two factors, academic achievement and type of laboratory activity, have no significant influence on the F2 of student's attitude towards physics with $p = .112$ and $p = .214$, respectively. This indicates that students' unwillingness to learn physics course is influenced by their neither academic achievement nor the type of laboratory activity that they take. Furthermore, the interaction of the academic achievement factor and type of laboratory activity, has no significant effect on students' unwillingness to learn physics. Nevertheless, Figure 2 shows how the group who took the PCILA were recorded to have lower averages for F2, that is the students who answered the enhanced laboratory activity were less unwilling to learn the physics course.

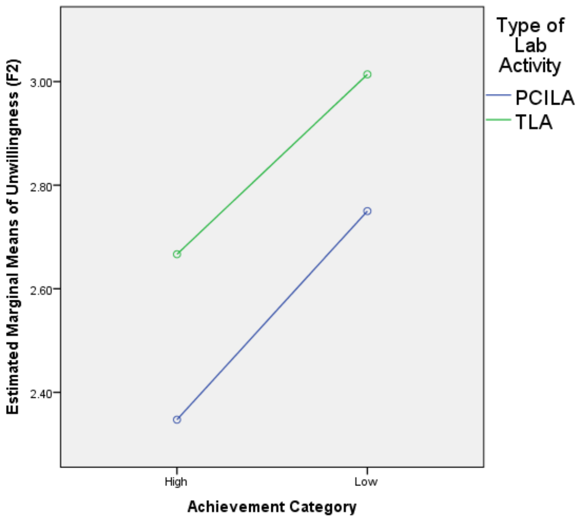

Figure 2. ***Academic Achievement and Type of Lab Activity Interaction***

It can also be gleaned from the plots in Figure 2 that the less performing students are more unwilling to learn the physics course and the high achieving students are less unwilling to learn the physics course regardless of the type of laboratory activity that they take.

Academic Self (F3)

The data gathered from the sample are normally distributed and there are equal variances across each group for the third factor of attitude towards physics, academic self. Just as the other factors, interest and unwillingness, the assumptions for a parametric test are met.

Table 10. ***Shapiro-Wilk Test of Normality (F3)***

Factor	Motivation	Shapiro-Wilk Statistic	df	Sig.
Academic Self (F3)	High	.951	24	.288
	Low	.969	24	.641
	Lab Activity	Statistic	df	Sig.
Academic Self (F3)	PCILA	.940	24	.159
	TLA	.978	24	.862

*p < 0.05.

Table 11. ***Levene's Test of Equality of Error Variances (F3)***

F	df1	df2	Sig.
1.831	3	44	.155

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Table 12. ***Analysis of Variance Between Effects of Academic Achievement and Type of Lab Activity on Academic Self (F3)***

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.345[a]	3	1.115	1.746	.172	.106
Intercept	379.875	1	379.875	594.844	.000	.931
Achievement Category	1.367	1	1.367	2.140	.151	.046
Type of Lab Activity	.827	1	.827	1.295	.261	.029
Achievement Category * Type of Lab Activity	1.151	1	1.151	1.803	.186	.039
Error	28.099	44	.639			
Total	411.319	48				
Corrected Total	31.444	47				

Note: at 95% confidence interval

A similar result from the two previous factors of attitude can be seen for both academic achievement and type of laboratory activity in terms of the *academic self* factor. With $p > .05$, it indicates that the academic achievement of the students and the laboratory activity based on the traditional and enhanced structure have no significant effect on the way students view themselves as academically successful in their physics course.

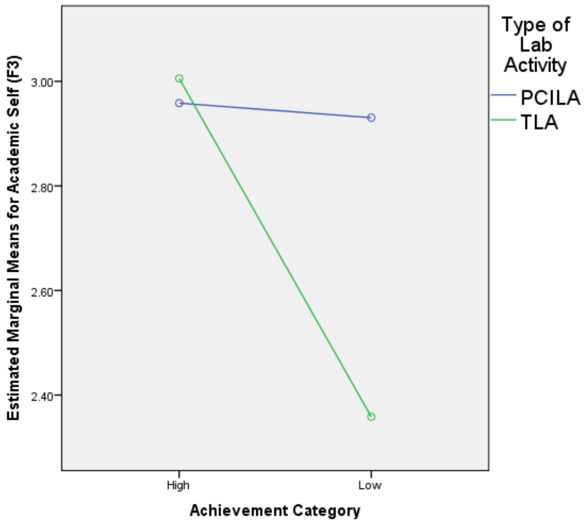

Figure 3. ***Academic Achievement and Type of Lab Activity Interaction (F3)***

Figure 3 shows that compared to the group who took the TLA, the students in the group who took the PCILA lesser deviation in the averages in the third factor, academic self. This indicates that the students in the PCILA with either high or low achievement in the physics course see themselves as successful in their physics course. Furthermore, the students who took the traditional laboratory activity and have low achievement in physics view themselves as more unsuccessful in the physics course than any other groups.

Necessity

Table 13. ***Shapiro-Wilk Test of Normality (F4)***

		Shapiro-Wilk		
Factor	Motivation	Statistic	df	Sig.
Necessity (F4)	High	.904	24	.026
	Average	.953	24	.322
	Lab Activity	Statistic	df	Sig.
Necessity (F4)	PCILA	.938	24	.149
	TLA	.908	24	.032

*$p < 0.05$.

Table 14. ***Levene's Test of Equality of Error Variances***

F	df1	df2	Sig.
3.373	3	44	.027

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

It can be gleaned from the results of the results of the Shapiro-Wilk test and the Levene's Test that the data for the factor being measured is not normally distributed and that the variances are equal in each group. Although this is the case the Two-way ANOVA can tolerate small violations such as the normality of the distribution especially since the sample sizes of each group in the study are equal. Thus, ANOVA (Two-Factorial) was still utilized to test the hypothesis.

Table 15. ***Analysis of Variance Between Effects of Motivation and Type of Lab Activity on Necessity (F4)***

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.617[a]	3	.206	.367	.777	.024
Intercept	541.363	1	541.363	965.936	.000	.956
Achievement Category	.333	1	.333	.595	.445	.013
Type of Lab Activity	.270	1	.270	.482	.491	.011
Achievement Category * Type of Lab Activity	.013	1	.013	.024	.878	.001
Error	24.660	44	.560			
Total	566.640	48				
Corrected Total	25.277	47				

Note: at 95% level of significance

Given by the $p > .05$ presented in Table 15 for the independent variables (academic achievement and type of activity) indicates that the two factors do not significantly influence the way students view studying physics as necessary to be studied. Such value dictates that the null hypothesis is ones again failed to be rejected. The interaction of the two variables neither enhance nor limits the students to view physics as a course necessary to be studied. Furthermore, Figure 4 reveals that students with higher academic achievement tend to view physics as a necessity more than the students with lower academic achievement. The group who was given the PCILA had higher averages for the necessity factor (F4) than the group who was given the TLA.

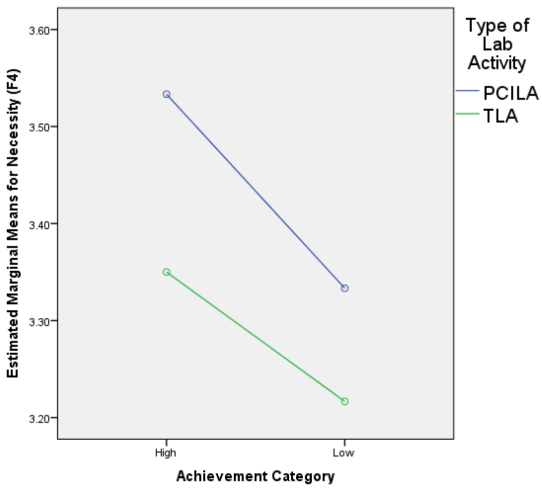

Figure 4. ***Academic Achievement and Type of Lab Activity Interaction (F4)***

Discussion

The study demonstrated how students' academic achievement and enhanced laboratory activity may be related to students' attitude towards their physics course in the hopes to address students' negative attitude towards physics. The individual effects variables were analyzed as well as their interaction to have a more wholistic view of the study.

Academic Achievement and Attitude Toward Physics

The results of the study conducted as summarized in Table 16 reveals that among all the factors of attitude toward physics measured only the interest (F1) to study physics course of the students is influenced by the factor academic achievement. Such result agrees with the previously conducted studies on the relationship between achievement and attitude toward physics (Wilson, 1983; Shabbir Ali & Awan, 2013; Mao et. al., 2021). However, this result suggests that other aspects of students' attitude toward physics may not always be directly related to or influence by the academic achievement of students.

Table 16. *Analysis of Variance for Academic Achievement and Attitude Towards Physics*

Attitude Towards Physics Factors	F	Sig
Interest (F1)	4.489	.040
Unwillingness (F2)	2.624	.112
Academic Self (F3)	2.140	.151
Necessity (F4)	.595	.445

*p < .05.

Physics Laboratory Activity and Attitude Towards Physics

The results for the effect of the laboratory activity based on traditional and enhanced structure on students' attitude toward physics course of its four factors is uniform. The laboratory activity taken by the students with either the traditional and enhance structure appears to have no different effect on attitude towards physics who have high and low academic achievement in physics. This result was not initially predicted as the two structures were although visually similar, the additional questions were considerably cognitive and reflective. These results may have been influenced by the limited sample size used in the study since using a bigger sample size would statistically increase the likelihood of rejecting the null hypothesis.

Table 17. *Analysis of Variance for Laboratory Activity and Attitude Towards Physics*

Attitude Towards Physics Factors	F	Sig
Interest (F1)	2.844	.099
Unwillingness (F2)	1.587	.214
Academic Self (F3)	1.295	.261
Necessity (F4)	.482	.491

*p < .05.

Interaction of Academic Achievement and Laboratory Activity

As it was found that the academic achievement and laboratory activity based on traditional (TLA) and enhanced structures (PCILA) have no significant effect on no significant students' attitude toward physics, the following are the significant findings drawn from the data:

a) Students with high academic achievement and provided with the PCILA had the greatest average for interest (F1) in physics.
b) The students with either high or low academic achievement who took the PCILA had are more willing to learn physics than the students who took the TLA.

c) The group who answered the enhanced laboratory activity (PCILA) view themselves to be successful in their physics course more than the group who took the TLA. This result could be attributed to the complexity of the questions and time factor added by the enhanced laboratory activity. Accomplishing the enhanced laboratory activity boosted the academic self-view of the students even with low academic achievement.
d) Regardless of the academic achievement, the group who took the PCILA are reported to have viewed physics course as necessary for them to learn for their future academic path more than the group who took the TLA.

Conclusions

Despite the negative views of learners toward learning physics, it remains as an essential and integral part of the basic education curriculum especially in the STEM strand (Nava & Camarao, 2017). Although academic achievement was found to have a positive relationship with attitude toward physics (Wilson, 1983; Shabbir Ali & Awan, 2013; Mao et. al., 2021) the result of the study tells us that other factors associated with students' attitude may not be directly influenced by academic achievement. A significant finding of the study is how neither the academic achievement level nor laboratory activity based on traditional and enhanced laboratory activity can influence all the factors of attitude toward physics. The overarching results reveal that the academic achievement and laboratory activities cannot be a direct predictor students' attitude toward physics. Furthermore, the interaction of the two variables was revealed to have no direct influence on student's attitude toward physics. These results are associated with the limited participants included in the study as well as the delimitations set by time constraints. Nevertheless, these results verify the results in recent studies on the interaction attitude and laboratory activities particularly addressing the incongruence in the older and newer results of studies about the effect of laboratory activities on students' attitudes. The results of the current study agrees more with the results of the recent studies than the older studies. This study contributes to the growing premise in physics education that laboratory activities doesn't directly influence students' attitude towards physics and thus, must not be a basis for students' positive view of physics. (Snetinova, et. al., 2018; Ernita, et. al., 2021).

The researcher recommends replicating the study with greater sample size to better represent the population and to decrease the likelihood of committing a type II error. Repeated measures such as pre-and-point test must be conducted for a firmer result. Further investigation about the effect of laboratory activity on attitude toward physics is recommended, perhaps the variable connecting the affective aspect of attitude and cognitive aspect of laboratory activity.

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