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Acceptability and effectiveness of PhET simulation-based interventional material in improving the academic performance in physics among grade 8 students

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Abstract

This study investigated the effectiveness and acceptability of a PhET Simulation-Based Intervention Material to enhance Grade 8 learners' comprehension of the law of acceleration, aligning with inclusive learning goals in the K to 12 Basic Education Curriculum. Employing a classroom-based action research approach, the study explored how the intervention influenced academic performance and its acceptability among teacher-respondents, considering gender, educational attainment, and school type. Results demonstrated that the PhET Simulation-based intervention led to significant improvement in Grade 8 learners' academic performance, evident through higher posttest scores compared to pretest scores. Notably, the intervention material received substantial acceptability from teacher-respondents across different demographics, such as gender, educational attainment, and school type. Although correlations are noted, the analyses indicate slight or non-significant connections between demographic factors and acceptability levels. The study recommended that educators incorporate simulation-based materials in teaching methods and that educational institutions provide training for effective tool utilization. Future research should explore diverse samples and additional variables impacting intervention acceptability, contributing to a more profound comprehension of implementation and efficacy. The study's implications underscore the potential of technology-assisted learning tools to enhance comprehension, stress the importance of matching interventions with educators' preferences, and underscore the necessity for further investigation into the intricate interplay between interventions, individual attributes, and learning outcomes for informed teaching strategies.

Keywords: Intervention Material; Law of Acceleration; Phet Simulation; Performance In Science; Innovative Tool

1. Introduction

Inclusive learning is one of the thrusts of the K to 12 Basic Education Curriculum (Deped Order No. 21, 2019; DepEd Order No. 72, 2009). This thrust ensures all learners are given an equal chance to grow through varied learning activities (RA 10533).

The performance of learners and teachers is measured and can be done through the mean percentage score (MPS) (Obaob & Moneva, 2021). Meanwhile, the Agusan del Sur Division MPS in Science 8 of the first quarter of School Year 2021- 2022 was 61.92. This indicates that the learners are performing poorly based on a 75 percent passing rate. The low MPS signified that there are learners who are being tested with low mastery of concepts. Correspondingly, having a low MPS is one of the concerns of DepEd.

The low academic achievement rate posed a significant challenge to the education sector (Dumigsi & Cabrella, 2019). The factors affecting students' achievement in Science were students' misconceptions, gender, mathematical ability, and instructional materials.

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In addition, early assessments of the science curriculum focused on instructional materials, teachers, and facilities (Resurreccion and Adanza, 2015). Meanwhile, DepEd introduced the use of intervention materials as a form of remediation to increase the academic achievement of low-performing learners in addressing the problem in schools. DepEd Memorandum No. 117 s. 2005 strengthened teachers to develop, use intervention materials in classrooms, and apply appropriate learning interventions. Moreover, according to the study of Hasyim et al. (2020), it was confirmed that the PhET simulation helped students acquire science ideas in a statistically significant way.

The goal of the study was to test the acceptability and effectiveness of the intervention material as a remediation tool for the Grade 8 learners to improve their understanding of the law of acceleration.

2. Methodology

This study focused on improving the performance focusing on learning competency S8FE-Ia-15 (investigate the relationship between the amount of force applied and the mass of the object to the amount of change in the object's motion) through the use of PhET Simulation- Based Intervention Material among Grade 8 learners at Azpetia National High School, Azpetia, Prosperidad, Agusan del Sur, SY 2022-2023. This research focused on answering the following research problems: (1) What is the demographic profile of teacher-respondents in terms of: a. gender, b. educational attainment, and c. school type? (2) What is the academic performance of learner-respondents before the use of PhET Simulation-based intervention material? (3) What is the academic performance of learner-respondents after the use of PhET Simulation- based intervention material? (4) Is there a significant difference between before and after the use of PhET simulation-based intervention material? (5) What is the acceptability level of teacher-respondents? (6) Is there a significant difference of acceptability level among teacher respondents when grouped according to their profile? (7) Is there a significant relationship of acceptability among teacher-respondents between their profiles?

The classroom-based action research using a pretest-posttest design was employed to carry out this study. The researcher aimed to record, analyze, and interpret the results in the pretest and posttest of the respondents. This design also accommodated the generalization of findings of the study to the target population. The 32 grade 8 students of the same class from Azpetia National High School and the 37 teacher-respondents from the Municipality of Prosperidad were the respondents of this research. A 30-item pretest was administered to the student-respondents. After that, a PhET Simulation-based intervention material was implemented to the respondents. The lesson in the intervention was read, performed, and studied by the students, and the researcher directed the students to learn in the context of their own personal experiences.

Then, a posttest was conducted after using the material. Their scores in every treatment were recorded and interpreted by the researcher. To determine whether there were significant differences in their mean percentage scores in the pretest and posttest, a t-test for two means was used. The profile of the teacher-respondents was also recorded and analyzed. The acceptability level of using the material was also taken into account based on the profile. ANOVA was used to determine the significance between groups, and Pearson r was utilized to identify the relationship between groups.

3. Results and analysis

Statistically, the problems of the study were answered by the following data gathered by the researcher.

Demographic profile of the teacher-respondents in terms of:

3.1. Gender

Table 1 Number of teacher-respondents according to gender

Frequency			Percent	Valid Percent	Cumulative Percent
Valid	Male	11	29.7	29.7	29.7
	Female	26	70.3	70.3	100.0
	Total	37	100.0	100.0	

From the data in the table, out of 37 teacher-respondents, 11 (or 29.7%) are male, and 26 (or 70.3%) are female.

3.2. Educational Attainment

Table 2 Number of teacher-respondents according to educational attainment.

Frequency		Percent	Valid Percent	Cumulative Percent
Bachelor's Degree	11	29.7	29.7	29.7
With MA Degree or units	19	51.4	51.4	81.1
With PhD Degree or units	7	18.9	18.9	100.0
Total	37	100.0	100.0	

Based on Table 2, among the teacher-respondents, 11 (or 29.7%) have a Bachelor's Degree, 19 (or 51.4%) have an MA Degree or units, and 7 (or 18.9%) have a PhD Degree or units.

3.3. School Type

Table 3 Number of teacher-respondents according to school type

Frequency			Percent	Valid Percent	Cumulative Percent
Valid	Rural	13	35.1	35.1	35.1
	Urban	24	64.9	64.9	100.0
	Total	37	100.0	100.0	

In this table, among the teacher-respondents, 13 (or 35.1%) are from rural schools, and 24 (or 64.9%) are from urban schools.

3.4. Academic Performance in Pretest

Academic performance of learner-respondents before the use of PhET Simulation-based intervention material:

Table 4 Academic performance before the use of PhET Simulation-based intervention material

N		Minimum	Maximum	Mean	Std. Deviation
Pretest	32	2	27	13.97	7.105
Valid N (listwise)	32				

Table 4 provides a summary of the academic performance of the learner respondents on the pretest. The average score was approximately 13.97 out of a possible range of 2 to 27. The relatively high standard deviation of 7.105 indicates that there was a notable variability in the scores, suggesting that some learner-respondents performed well above the mean while others scored below it. This information serves as a baseline for assessing any changes or improvements in academic performance after the intervention using the PhET Simulation-based materials.

3.5. Academic Performance in Posttest

Table 5 Academic performance after the use of PhET Simulation-based intervention material

N		Minimum	Maximum	Mean	Std. Deviation
Posttest	32	4	30	16.13	7.525
Valid N (listwise)	32				

Academic performance of learner-respondents after the use of PhET Simulation-based intervention material

Table 5 provided a summary of the academic performance of the learner respondents on the posttest after they had undergone the intervention using the PhET Simulation-based materials. The average posttest score was approximately 16.13 out of a possible range of 4 to 30. Comparing this to the pretest mean score of 13.97, there seems to be an improvement in academic performance after the intervention. The standard deviation of

7.525 indicates variability in the scores, suggesting that some learner-respondents experienced a greater improvement than others. This information provides insight into the effectiveness of the intervention in enhancing the academic performance of the participants.

Significant difference between before and after the use of PhET simulation-based intervention material:

3.6. T-test of Pretest-Posttest

Table 6 t-test results between pretest and posttest

Paired Differences						**Significance**			
Mean		**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**		**t value**	**df**	**One-Sided p**	**Two-Sided p**
				Lower	Upper				
Pair Pretest – Posttest	-2.156	1.851	0.327	-2.824	-1.489	-6.590	31	<0.001	<0.001

level of significance: α=0.05

Based on the table 6, the p-value is much smaller than 0.05 (α), indicating strong evidence to reject the null hypothesis. Therefore, there is a significant difference between the academic performance of learner-respondents before and after the use of the PhET simulation-based intervention material. The p-value being < 0.001 indicates an extremely low probability of obtaining such results by random chance alone. This finding aligned with the level of significance and suggested that the intervention material had a meaningful impact on the academic performance of the learner-respondents.

3.7. Acceptability Level by Gender

Table 7 Acceptability Level according to gender

Gender Mean		**N**	**Std. Deviation**	**Interpretation**
Male	3.6182	11	0.72086	Highly Acceptable
Female	3.5308	26	0.49539	Highly Acceptable
Total	3.5568	37	0.56250	Highly Acceptable

Considering gender-based groups, both male (mean = 3.6182) and female (mean = 3.5308) teacher-respondents exhibited a high level of acceptability towards the intervention material. The overall acceptability level across all genders (mean = 3.5568) was also categorized as highly acceptable. This indicated that the intervention material was well-received and favorably perceived by both male and female teacher respondents.

3.8. Educational Attainment

Table 8 Acceptability Level according to gender

Educational Attainment	**Mean**	**N**	**Std. Deviation**	**Interpretation**
Bachelor's Degree	3.7364	11	0.65310	Highly Acceptable
With MA Degree or units	3.4579	19	0.51888	Moderately Acceptable

With PhD Degree or units	3.5429	7	0.53807	Highly Acceptable
Total	3.5568	37	0.56250	

Based on Table 8, teacher-respondents with Bachelor's Degrees (mean = 3.7364) and those with PhD Degrees or units (mean = 3.5429) found the intervention material to be highly acceptable. However, teacher-respondents with MA Degrees or units (mean =3.4579) demonstrated a moderately acceptable level of acceptance. Overall, the intervention material was perceived positively by all educational attainment groups, with Bachelor's and PhD Degree holders showing particularly high levels of acceptability.

3.9. School Type

Table 9 Acceptability level according to school type

School Type	Mean	N	Std. Deviation	Interpretation
Rural	3.3538	13	0.61862	Moderately Acceptable
Urban	3.6667	24	0.50962	Highly Acceptable
Total	3.5568	37	0.56250	Highly Acceptable

Based on Table 9, teacher-respondents from urban schools (mean = 3.6667) exhibited a highly acceptable perception of the intervention material, while those from rural schools (mean = 3.3538) indicated a moderately acceptable level of acceptance. Overall, the intervention material was well-received, with urban schools demonstrating a particularly high level of acceptability.

ANOVA Test of acceptability level among teacher-respondents when grouped according to their profile:

3.10. ANOVA Tests of Between-Subjects Effects

Table 10 ANOVA tests between groups

ANOVA Tests of Between-Subjects Effects					
Dependent Variable: Acceptability Level					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	5.234[a]	10	0.523	2.210	0.051
Intercept	285.615	1	285.615	1206.172	<0.001
Gender	0.094	1	0.094	0.395	0.535
Educational Attainment	0.267	2	0.133	0.563	0.576
School Type	7.062E-5	1	7.062E-5	0.000	0.986
Gender * Educational Attainment	0.876	2	0.438	1.849	0.178
Gender * School Type	**0.135**	**1**	**0.135**	**0.569**	**0.457**
Educational Attainment * School Type	1.055	2	0.528	2.228	0.128
Gender * Educational Attainment * SchoolType	1.895	1	1.895	8.002	0.009
Error	6.157	26	0.237		
Total	479.460	37			
Corrected Total	11.391	36			

R Squared = .460 (Adjusted R Squared = .252); *level of significance: α=0.05*

Based on Table 10, the analysis examined whether there is a significant difference in acceptability levels among teacher-respondents when grouped according to their profiles. The overall model's significance ($F = 2.210$, $p = .051$) suggests that there might be some effect, but it falls just short of the conventional significance threshold ($\alpha = 0.05$). The interaction between gender, educational attainment, and school type significantly influenced acceptability levels ($p = .009$), contributing to about 25.2% of the variance in the acceptability levels.

Pearson correlation test of acceptability level among teacher-respondents between their profiles:

3.11. Gender

Correlations between Gender and Acceptability Level

Table 11 Pearson correlation test of acceptability level between gender

Gender	**Acceptability Level**		
Gender	Pearson Correlation	1	-0.072
	Sig. (2-tailed)		0.672
	N	37	37

The Pearson correlation analysis examined the relationship between gender and acceptability level among teacher-respondents. The very weak negative correlation coefficient of -0.072 indicated that there is hardly any association between gender and acceptability level.

This finding is supported by the non-significant p-value of 0.672, confirming that gender has no statistically significant impact on acceptability level at the 0.05 significance level.

3.12. Educational Attainment

Table 12 Pearson correlation test of the acceptability level between educational attainment

Educational Attainment	**Pearson Correlation**	**1**	**-.147**
	Sig. (2-tailed)		.387
	N	37	37

The Pearson correlation analysis investigated the relationship between educational attainment and acceptability level among teacher-respondents.

3.13. Educational Attainment Acceptability Level

The correlation coefficient of –0.147 signifies a weak negative correlation, suggesting a slight tendency that higher educational attainment is associated with slightly lower acceptability, though the correlation is not substantial. The p-value of 0.387 indicates that this relationship is not statistically significant at the 0.05 significance level, implying that there's insufficient evidence to claim a meaningful connection between educational attainment and acceptability level.

3.14. School Type

Correlations between School Type and Acceptability Level

Table 13 Pearson correlation test of acceptability level between school type

	Acceptability Level		
School Type	Pearson Correlation	1	0.269
	Sig. (2-tailed)		0.107
	N	37	37

The Pearson correlation analysis explored the relationship between school type and acceptability level among teacher-respondents. The correlation coefficient of 0.269 suggests a weak positive correlation, indicating a minor tendency that teachers from urban schools have slightly higher acceptability levels. However, the correlation is not strong enough to be significant, as confirmed by the p-value of 0.107, which is greater than the 0.05 significance level. Consequently, there is insufficient statistical evidence to conclude that school type significantly affects acceptability level.

4. Conclusion

This study's findings reveal that the utilization of the PhET Simulation-based intervention material led to a statistically significant improvement in the academic performance of Grade 8 learners. This improvement was evident through a notable increase in posttest scores compared to pretest scores. Additionally, the material garnered a high level of acceptability among teacher-respondents, irrespective of gender, educational attainment, or school type. However, while trends were observed, the correlation analyses indicated weak or non-significant relationships between these demographic factors and acceptability levels.

Recommendations

Based on the study's outcomes, several recommendations can be made to enhance both teaching practices and future research endeavors. Educators are encouraged to integrate simulation-based intervention materials, such as the PhET simulations, into their pedagogical strategies to foster conceptual understanding of physics concepts. Furthermore, educational institutions should consider providing workshops or training sessions to familiarize teachers with the effective use of simulation tools. Future research could explore more diverse samples and additional variables that may influence acceptability levels, contributing to a more comprehensive understanding of intervention implementation and effectiveness.

4.1. Implications

The implications of this study are manifold and hold relevance for educators, policymakers, and researchers. The demonstrated effectiveness of the PhET Simulation-based intervention material signifies the potential of technology-enhanced learning tools in enhancing student understanding of complex scientific concepts. The high acceptability levels among teacher-respondents underscore the importance of aligning educational interventions with teachers' preferences and needs. Moreover, the study highlights the need for further investigation into the interplay between educational interventions, individual characteristics, and their combined impact on student learning outcomes, thereby guiding the development of evidence-based teaching strategies.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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