TPM Vol. 32, No. S4, 2025
ISSN: 1972-6325
https://www.tpmap.org/

A STUDY ON INTERACTIVE SIMULATIONS FOR TEACHING LENSES FOR X STANDARD GIRLS STUDENTS

USHA RANI. L. P[1], Dr. NAGA SUBRAMANI. P.C[2]

[1]PH.D. RESEARCH SCHOLAR, DEPARTMENT OF PEDAGOGICAL SCIENCES, TAMIL NADU TEACHERS EDUCATION UNIVERSITY, KARAPAKKAM, CHENNAI, TAMIL NADU.
[2]PROFESSOR, DEPARTMENT OF PEDAGOGICAL SCIENCES, TAMIL NADU TEACHERS EDUCATION UNIVERSITY, KARAPAKKAM, CHENNAI, TAMIL NADU.

Abstract
This research is made to study interactive simulations for teaching lenses for X standard Girls students. The sample of the study consists of 160 X Standard Students and among them, 88 are Boys Students and 72 Girls Students. In order to study the objectives, Solomon four group experimental design has employed. The X Standard Students in control group were taught Lenses by using Conventional Design. The X Standard Students in experimental group were taught Lenses through Interactive Simulations. The results reveal that X Standard Girls in experimental groups of both PPT design and PT design have excelled in learning Lenses by means of Interactive Simulations for Teaching Lenses than control groups have gone through in learning of Lenses in Conventional Design in both PPT design and PT design. The post test scores of X Standard Girls in both experimental and control groups are higher than their pre test scores in PPT design. The post test scores of X Standard Girls in experimental group of PPT design are lesser than the post test scores of XI Standard Girls in experimental group of PT design. Thus, it is concluded that Teaching Lenses through Interactive Simulations is having positive impact on their learning Lenses than through Conventional Design and Interactive Simulations is having higher impact on learning Lenses among X Standard Girls. Therefore, it is concluded that Teaching Lenses through Interactive Simulations is having positive effect on their learning Lenses than through Conventional Design and Interactive Simulations is highly effective for learning Lenses among X Standard Girls.

Keywords: Interactive Simulations, Lenses, Solomon Four Group Design, Teaching.

INTRODUCTION

Interactive simulations are the vibrant digital models of actual world system or situations which are permitting students or learners for participating actively in learning by means of operate concepts, taking rational decision(Correia et al. 2019) and looking instantaneous, outcomes of casual relations in a safe atmosphere which are improving their learning activities(Ismalia et al 2022). Interactive simulations are helping students and teachers for creating student oriented classroom through understanding and acknowledging ideas of students, encouraging students for their active learning(Sitindaon et al. 2020) and properly directing them, building their previous knowledge, recognizing and dealing their multiple objectives, adjusting activities to their atmosphere and students and improving their professional learning(Salazar, 2021). Interactive simulations are a group of interactive and research based simulations that are highly improved understanding of different notions, ideas, theories and content of subject among students (Banda and Nzabahimana, 2023) and it making connectivity and giving access to students for conceptual models through visualization and removing gap among actual world situations and theoretical concepts(Taibu et al. 2021).

Interactive simulations are highly improving understanding capabilities of students towards various complicated and difficult concepts very easily and are integrating them in to different learning atmospheres (Wieman et al. 2010) and they are improving learning through active involvement of students and in turn they are increasing their motivation and engagement leading to retention of higher knowledge and process skills (Laurence, 2022) and they are also helping students to enhance their, understanding capability of concepts, problem solving and decision making abilities significantly(Supurwoko et al. 2016). Interactive simulations are providing instantaneous feedback, letting to making immediate and quick corrective measures and swift acquisition of skills among students(Labadlabad, 2025) and they are intensively using by both teachers and students for their effective teaching and learning of various complicated portion of science subjects. Therefore, it is imperative to study interactive simulations for teaching lenses for X standard Girls students.

REVIEW OF EARLIER STUDIES

Silva and Vasconcelos (2026) found that interactive simulations within the 5E-FLEX model had positively and significantly impacting engagement, autonomy and learning experience of pre service chemistry students. Besides, it had also improved process in learning, performing more number of tests, personal experience and understanding of concepts and theories.

Uthman et al (2025) concluded that integrated STEM modules enhanced with computer simulations had increased performance of senior secondary school students in physics and chemistry subjects belonging to experimental group as against control group and significant disparity was seen among these groups regarding to their performance. Hence, integrated STEM modules enhanced with computer simulations had positive and significant effect on performance in chemistry and physics subjects among senior secondary school students.

Eleo and Manguilimotan (2024) revealed that physics education technology (PhET) interactive simulations had increased performance of Grade 11 senior high school students in physics subject. The mean value of performance in physics in post test for experimental group was higher as against control group Grade 11 senior high school students and significant difference in performance was existed among experimental and control groups.

Rico et al (2023) indicated that simulations based learning had significant improved understanding of subject among under graduate students and it had also increased their academic achievement and critical thinking. Under graduate students in experimental group had higher degree of academic achievement and critical thinking as comparing to control group and significant difference was observed among these groups in academic achievement and critical thinking.

Sibinda and Shumba (2022) showed that PhET interactive simulations and power point slide presentation had worked better and was effective among grade 10 students. Interactive simulations were highly effective as compared to power point presentation in visualizing chemical equations among grade 10 students. Grade 10 students in PhET interactive simulation group had higher degree of attitude and achievement in learning of chemical equations in comparing to those in power point presentation group.

Taneo and Moleno (2021) found that PhET interactive simulation had increased performance of grade 8 students in physics subject and significant disparity was witnessed among pre and post test scores among PhET interactive simulation and lecture method. Besides, significant relation was existed among attitude towards PhET interactive simulation performance score in physics of grade 8 students in post test exposed with PhET interactive simulation strategy.

Garcia (2020) concluded that PhET interactive simulations were improving performance of grade 8 students in mathematics subject and it was differing significantly among scores in mathematics of pre and post tests. Grade 8 students in experimental groups had showed higher degree of performance in mathematics subject than control group students.

Ngatia et al (2019) revealed that interactive multimedia simulations had positive and significant impact on achievement of secondary school students in physics subject. Secondary school students taught through interactive multimedia simulations had exhibited improved achievement in comparing to those taught by means of conventional teaching methods.

Sreelekha (2018) indicated computer simulation and video based instructional strategies had positive and significant effect on practical physics test of SS II physics students. Students in experimental group had higher acquisition of skills practical physics as opposed to those were in control group. Thus, use of mputer simulation and video based instructional strategies had improved acquisition of skills practical physics among SS II physics students significantly.

OBJECTIVES OF THE STUDY

1. To find out the significant difference between Experimental group (Interactive Simulations for Teaching Lenses) Girls and Control group (Conventional Design for Teaching Lenses) Girls in X Standard Students learning Lenses.

HYPOTHESES OF THE STUDY

There is no significant difference between the pre test and post test scores of experimental group Girls in PPT design.

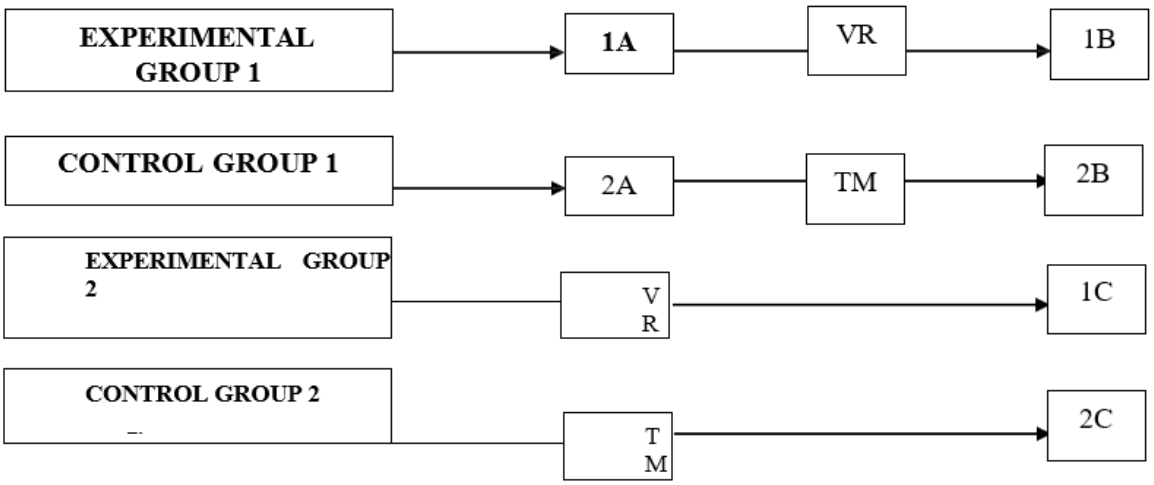
1. There is no significant difference between the pre test scores of control group Girls in PPT design and post test scores of control group Girls in PPT design.
2. There is no significant difference between the pre test scores of experimental group Girls in PPT design and pre test scores of control group Girls in PPT design.
3. There is no significant difference between the post test scores of experimental group Girls in PPT design and post test scores of control group Girls in PPT design.
4. There is no significant difference between the post test scores of experimental group Girls in PT design and post test scores of control group Girls in PT design.
5. There is no significant difference between the pre test scores of control group Girls in PPT design and post test scores of control group Girls in PT design.
6. There is no significant difference between the post test scores of experimental group Girls in PPT design and post test scores of experimental group Girls in PT design.

7. There is no significant difference between the post test scores of control group Girls in PPT design and post test scores of control group Girls in PT design.

METHODOLOGY

This study is carried out in Thoothukudi district of Tamil Nadu. The sample of this study is 160 X Standard Students and they are drawn from Ravilla KRA Vidyalaya CBSE School, Kovilpatti, Thoothukudi district and Edustar International School, Kovilpatti Thoothukudi district of Tamil Nadu. Amongst them, 88 are Boys Students and 72 are Girls Students. For the purpose of studying the objectives, Solomon four group experimental design is applied and is illustrated in Figure-1 and it is a blend of the pre test-post test control group design and the post test only control group design. The X Standard Students in control group are taught Lenses through Conventional Design. The X Standard Students in experimental group are taught Lenses through Interactive Simulations and the measures are taken for minimizing or controlling the threats to internal and external validity rationally.

FIGURE-1. SOLOMON FOUR GROUP EXPERIMENTAL DESIGN



1. 1A - EG1 - Pre test
2. 2A - CG1 - Pre test
3. 1B - EG1 - Post test
4. 2B - CG1 - Post test
5. 1C - EG2 - Post test
6. 2C - CG2 - Post test

The tools namely Criterion test on Teaching Lenses through Interactive Simulations for X Standard Girls Students and app-Video Explanation for Lenses are used in the this study. The Pre and Post- tests are conducted among Group I and Group II. The post test only design (PT design) is conducted for Group III and Group IV. The investigator has developed app for Interactive Simulations for teaching Lenses. The two Experimental groups' with sample of 36 X Standard Girls Students and each of them are subjected to treatment and these students are taught Lenses through Interactive Simulations. The two Control groups' with sample of 36 X Standard Girls Students and each of them are subjected to Conventional Design.

RESULTS HYPOTHESES TESTING

Hypothesis-1: There is no significant difference between the pre test and post test scores of experimental group Girls in PPT design.

Table-1. Pre Test and Post Test Scores of Experimental Group Girls in PPT Design

Variable	N	Mean	SD	t-Value	Sig.
PPT(Experimental Girls) - Pre Test	18	19.39	2.83	20.090	.000
PPT(Experimental Girls) - Post Test	18	39.44	2.85		

From the above table, it is seen that the calculated 't' value of 20.090 is higher than the critical value of 2.90 in 1% level of significance. Hence, it is concluded that there exists significant difference between the pre test and post test scores of experimental group Girls in PPT design. The mean value of the post test (39.44) scores of

experimental group Girls in PPT design is higher than the mean value of pre test (19.39) scores of experimental group Girls in PPT design. Thus, the hypothesis is rejected. The experimental group Girls in PPT design has performed very well after the experiment. It is interpreted that Interactive Simulations for Teaching Lenses is having better impact on X Standard Girls Students in learning Lenses in PPT design.

Hypothesis-2: There is no significant difference between the pre test scores of control group Girls in PPT design and post test scores of control group Girls in PPT design.

Table-2. Pre Test Scores of Control Group Girls in PPT Design and Post Test Scores of Control Group Girls in PPT Design

Variable	N	Mean	SD	t-Value	Sig.
PPT(Control Girls) - Pre Test	18	22.17	1.47	11.723	.000
PPT(Control Girls) - Post Test	18	31.56	3.17		

From the above table, it is observed that the calculated 't' value of 11.723 is higher than the critical value of 2.90 in 1% level of significance. Hence, it is concluded that there exists significant between the pre test scores of control group Girls in PPT design and post test scores of control group Girls in PPT design. The mean value of the post test scores of control group Girls (31.56) in PPT design is higher than the mean value of pre test scores of control group Girls (22.17) in PPT design. Thus the hypothesis is rejected. The pre test scores of control group Girls in PPT design is smaller than the post test scores of control group Girls in PPT design. **Hypothesis-3:** There is no significant difference between the pre test scores of experimental group Girls in PPT design and pre test scores of control group Girls in PPT design.

Table-3. Pre Test Scores of Experimental Group Girls in PPT Design and Pre Test Scores of Control Group Girls in PPT Design

Variable	N	Mean	SD	t-Value	Sig.
PPT(Experimental Girls) - Pre Test	18	19.39	2.83	3.651	.000
PPT(Control Girls) - Pre Test	18	22.17	1.47		

From the above table, it is observed that the calculated 't' value of 3.651 is higher than the critical value of 2.90 in 1% level of significance. Hence, it is concluded that there exists significant difference between the pre test scores of control group Girls in PPT design and post test scores of control group Girls in PPT design. Thus, the hypothesis is rejected. It is interpreted that the experimental group Girls and control group Girls are differed in PPT design.

Hypothesis-4: There is no significant difference between the post test scores of experimental group Girls in PPT design and post test scores of control group Girls in PPT design.

Table-4. Post Test Scores of Experimental Group Girls in PPT Design and Post Test Scores of Control Group Girls in PPT Design

Variable	N	Mean	SD	t-Value	Sig.
PPT(Experimental Girls) - Post Test	18	39.44	2.85	7.316	.000
PPT(Control Girls) - Post Test	18	31.56	3.17		

From the above table, it is clear that the calculated 't' value of 7.316 is higher than the critical value of 2.90 in 1% level of significance. Hence, it is concluded that there exists significant between the post test scores of experimental group Girls in PPT design and post test scores of control group Girls in PPT design. The mean value of the post test scores of experimental group Girls (39.44) in PPT design is higher than the mean value of post test scores of control group Girls (31.56) in PPT design. Thus, the hypothesis is rejected. The post test scores of control group Girls in PPT design is lesser than the post test scores of experimental group Girls in PPT design. It is interpreted that Interactive Simulations for Teaching Lenses is having better impact on X Standard Girls Students in learning Lenses than Conventional Design in PPT design.

Hypothesis-5: There is no significant difference between the post test scores of experimental group Girls in PT design and post test scores of control group Girls in PT design.

Table-5. Post Test Scores of Experimental Group Girls in PT Design and Post Test Scores of Control Group Girls in PT Design

Variable	N	Mean	SD	t-Value	Sig.
PT(Experimental Girls) - Post Test	18	42.39	0.85	12.852	.000
PT(Control Girls) - Post Test	18	32.61	3.52		

From the above table, it is evident that the calculated 't' value of 12.852 is higher than the critical value of 2.90 in 1% level of significance. Hence, it is concluded that there exists significant difference between the post test scores of experimental group Girls in PT design and post test scores of control group Girls in PT design. The mean value of the post test scores of experimental group Girls (42.39) in PT design is higher than the mean value of post test scores of control group Girls (32.61) in PT design. Thus, the hypothesis is rejected. The post test scores of control group Girls in PT design is lesser than the post test scores of experimental group Girls in PT design. It is interpreted that Interactive Simulations for Teaching Lenses is having better impact on X Standard Girls Students in learning Lenses than Conventional Design in PT design.

Hypothesis-6: There is no significant difference between the pre test scores of control group Girls in PPT design and post test scores of control group Girls in PT design.

Table-6. Pre Test Scores of Control Group Girls in PPT Design and Post Test Scores of Control Group Girls in PT Design

Variable	N	Mean	SD	t-Value	Sig.
PPT(Control Girls) - Pre Test	18	22.17	1.47	14.515	.000
PT(Control Girls) - Post Test	18	32.61	3.52		

From the above table, it is apparent that the calculated 't' value of 14.515 is higher than the critical value of 2.90 in 1% level of significance. Hence, it is concluded that there exists significant difference between the pre test scores of control group Girls in PPT design and post test scores of control group Girls in PT design. The mean value of the post test scores of control group Girls (32.61) in PT design is higher than the mean value of pre test scores of control group Girls (22.17) in PPT design. Thus, the hypothesis is rejected. The pre test scores of control group Girls in PPT design is lesser than the post test scores of control group Girls in PT design. It is interpreted that the normal difference is there between the scores of X Standard Girls Students before and after the subject has taught.

Hypothesis-7: There is no significant difference between the post test scores of experimental group Girls in PPT design and post test scores of experimental group Girls in PT design.

Table-7. Post Test Scores of Experimental Group Girls in PPT Design and Post Test Scores of Experimental Group Girls in PT Design

Variable	N	Mean	SD	t-Value	Sig.
PPT(Experimental Girls) - Post Test	18	39.44	2.85	3.850	.001
PT(Experimental Girls) - Post Test	18	42.39	0.85		

From the above table, it is seen that the calculated 't' value of 3.850 is higher than the critical value of 2.90 in 1% level of significance. Hence, it is concluded that there exists significant difference between the post test scores of experimental group Girls in PPT design and post test scores of experimental group Girls in PT design. The mean value of the post test scores of experimental group Girls (42.39) in PT design is higher than the mean value of post test scores of experimental group Girls (39.44) in PPT design. Thus, the hypothesis is rejected. It is interpreted that both experimental group Girls are having good impact in learning Lenses through Interactive Simulations for Teaching Lenses. The pre test and post test impact in PT design has influenced the X Standard Girls Students scores more than the scores of X Standard Girls Students in PPT design.

Hypothesis-8: There is no significant difference between the post test scores of control group Girls in PPT design and post test scores of control group Girls in PT design.

Table-8. Post Test Scores of Control Group Girls in PPT Design and Post Test Scores of Control Group Girls in PT Design

Variable	N	Mean	SD	t-Value	Sig.
PPT(Control Girls) - Post Test	18	31.56	3.17	0.828	.419

PT(Control Girls) - Post Test	18	32.61	3.52		

From the above table, it is observed that the calculated 't' value of 0.828 is lower than the critical value of 2.11 in 5% level of significance. Hence, it is concluded that there exists no significant difference between the post test scores of control group Girls in PPT design and post test scores of control group Girls in PT design. The mean value of the post test scores of control group Girls (32.61) in PT design is higher than the mean value of post test scores of control group Girls (31.56) in PPT design. Thus, the hypothesis is accepted. It is interpreted that the post test scores of control group Girls in PT design is higher than the post test scores of control group Girls in PPT design. It is interpreted that both control group Girls are having good impact in learning Lenses through Conventional Design. The pre test and post test impact in PT design has influenced the X Standard Girls Students scores more than the scores of X Standard Girls Students in PPT design.

SOLOMON FOUR GROUP ANALYSES – GIRLS

From the above findings, it observed that that the X Standard Girls in experimental groups of both PPT design and PT design have excelled in learning Lenses by means of Interactive Simulations for Teaching Lenses than control groups have gone through in learning of Lenses in Conventional Design in both PPT design and PT design.

The above findings explicate that the post test scores of X Standard Girls in both experimental and control groups are higher than their pre test scores in PPT design. It reveals that both deigns have impact on X Standard Girls' learning of Lenses. The above findings show that the pre test score of X Standard Girls in control group in PPT design is higher than the pre test score of experimental group in PPT design.

The above findings of cross comparison reveal that the post test scores of X Standard Girls in control group of PT design are higher than the pre test scores of X Standard Girls in control group of PPT design. It demonstrates that Conventional Design has impact on X Standard Girls' learning of Lenses.

Furthermore, the above findings explicate that the post test scores of X Standard Girls in control group of PPT design are lesser than the post test scores of X Standard Girls s in control group of PT design. The post test scores of X Standard Girls in experimental group of PPT design are lesser than the post test scores of XI Standard Girls in experimental group of PT design and it is because of the pre test impact on both experimental and control group Girls in PPT design.

The criterion test for Teaching Lenses through Interactive Simulations for X Standard Girls is shown in the following Table. It is inferred that Teaching Lenses through Interactive Simulations is having positive impact on their learning Lenses than through Conventional Design and Interactive Simulations is having higher impact on learning Lenses among X Standard Girls.

Table-9. Criterion Test for Teaching Lenses through Interactive Simulations for X Standard Girls

Variables	Significance	Remarks
PPT(Experimental) - Pre Test **PPT(Experimental) -Post Test**	**Significant**	**PPT(Experimental) - Post Test > PPT(Experimental) - Pre Test**
PPT(Control) -Pre Test **PPT(Control) - Post Test**	**Significant**	**PPT(Control) - Post Test > PPT(Control) - Pre Test**
PPT(Experimental) - Pre Test **PPT(Control) - Pre Test**	**Significant**	**PPT(Experimental) - Pre Test < PPT(Control) - Pre Test**
PPT(Experimental) - Post Test **PPT(Control) - Post Test**	**Significant**	**PPT(Experimental) - Post Test > PPT(Control) - Post Test**
PT(Experimental) - Post Test	**Significant**	**PT(Experimental) - Post Test >**

PT(Control) - Post Test		**PT(Control) - Post Test**
PPT(Control) - Pre Test **PT(Control) - Post Test**	**Significant**	**PT(Control) - Post Test** **>** **PPT(Control) - Pre Test**
PPT(Experimental) - Post Test **PT(Experimental) - Post Test**	**Significant**	**PPT(Experimental) - Post Test** **<** **PT(Experimental) - Post Test**
PPT(Control) - Post Test **PT(Control) - Post Test**	**Not Significant**	**PPT(Control) - Post Test** **<** **PT(Control) - Post Test**

CONCLUSION

The X Standard Girls in experimental groups of both PPT design and PT design have excelled in learning Lenses by means of Interactive Simulations for Teaching Lenses than control groups have gone through in learning of Lenses in Conventional Design in both PPT design and PT design. The post test scores of X Standard Girls in both experimental and control groups are higher than their pre test scores in PPT design. The post test scores of X Standard Girls in experimental group of PPT design are lesser than the post test scores of XI Standard Girls in experimental group of PT design. Thus, it is concluded that Teaching Lenses through Interactive Simulations is having positive impact on their learning Lenses than through Conventional Design and Interactive Simulations is having higher impact on learning Lenses among X Standard Girls.

REFERENCES

1. Abubakar Mahmood Uthman, Abdullahi Abubakar, & Salisu Harisu Usman.(2025). Impact of STEM-based learning using computer simulations on students' academic achievement in physics and chemistry at senior secondary school level. International *Journal of Scientific Research in Multidisciplinary Studies*, 11(7), 19-26.
2. Agilandeshwari U., & Naga Subramani P.C., (2024) "Effectiveness of Synetic Model in Teaching Grammar among VI Standard Students" *Educational Administration: Theory and Practice* p. 15948 – 15951
3. Alegria V. Garcia.(2020). Interactive simulations in teaching linear equations. *International Journal of Creative Research Thoughts*, 8(7), 4611-4617.
4. Banda, H. J., & Nzabahimana, J. (2023). The impact of physics education technology (PhET) interactive simulation-based learning on motivation and academic achievement among Malawian physics students. *Journal of Science Education and Technology*, 32(1), 127-141.
5. Correia, A. P., Koehler, N., Thompson, A., & Phye, G. (2019). The application of PhET simulation to teach gas behaviour on the submicroscopic level: Secondary school students' perceptions. Research in Science and Technological Education, 37(2), 193-217.
6. David G. Ngatia, Changeiywo, J., & Patricia W. Wambugu.(2019). Impact of interactive multimedia simulations advance organizers teaching approach on students' achievement in secondary school physics. *International Journal of Education and Research* 7(1), 279-290.
7. Heidy Rico, Mario Alberto de la Puente Pacheco, Adrian Pabon & Ivan Portnoy (2023) Evaluating the impact of simulation-based instruction on critical thinking in the Colombian Caribbean: An experimental study. *Cogent Education*, 10(2), 1-16.
8. Ismalia, I., Kusumawati, M., & Wahyuni, P. (2022). Investigating the use of phet simulation as a substitute for practical tools in understanding the concept of static electricity. *International Journal of Education and Teaching Zone*, 1(1), 20-25.
9. Jayantha Kumar Sreelekha.(2018). Effects of computer simulation and video based instructional strategies on students' acquisition of skills in practical physics. *International Journal of Educational Research and Technology*, 9(1),1-8.
10. Jeralden R. Labadlabad.(2025). Offline PhET Interactive Simulation-Based Enrichment Activities (OPISEA): Its effect on the academic performance of grade 8 students in science. *United International Journal for Research & Technology*, 6(6), 217-223,
11. Kale Andrea B. Salazar.(2021). Physics Education Technology (PhET) interactive simulation in student's learning skills in biology. *International Journal of Engineering Research and Management*, 8(12),1-6.

12. Laurence C. L. (2022). Integration of Phet interactive simulations in online synchronous and asynchronous teaching of science: It's impact on learners' science process skills. *International Journal of Trend in Scientific Research and Development*, 6(6), 61-77.
13. Liberty E. Taneo, & Ruth E. Moleno.(2021). Students' performance using Physics Education Technology (PhET) interactive simulation strategy. *Journal of Education & Social Policy*, 8(2), 52-55.
14. Melvin C. Eleo, & Ylcy B. Manguilimotan.(2024). Physics education technology (PhET) interactive simulations as teaching aid in enhancing students' performance in physics. *EPRA International Journal of Multidisciplinary Research*, 10(3), 60-64.
15. Nandhini G.,& Naga Subramani P.C., (2022) "Effectiveness Of Virtual Reality On Conceptualizaton Of Structure Of Heart And Pollination Among X Std Students" International Journal of Early Childhood Special Education Vol.14,Issue 08, P.2354- 2357
16. Nicholas Sibinda and Overson Shumba.(2022). The impact of PhET interactive simulations and powe rpoint presentation slide show visualisation on learning balancing of chemical equations among grade 10 pupils. *Journal of Applied Chemical Science International*, 13(1),1-5.
17. Silva R.A. & Vasconcelos F.C.G.C.(2026). Integrating interactive simulations in higher education: The 5E-FLEX model. *Discover Education,* 10(1),1-24.
18. Sitindaon, S. F., Bukit, N., & Turnip, B. M. (2020). The effect of guided inquiry learning using PhET media on students' problem-solving skills and critical thinking. *Journal of Education and Practice*, 8(21), 129-134.
19. Supurwoko, S., Cari, C., Sarwanto, S., Sukarmin, S., & Suparmi, S. (2016). The effect of Phet simulation media for physics teacher candidate understanding of photoelectric effect concept. In *International Journal of Science and Applied Science: Conference* Series, 1(1),33-39.
20. Taibu, R., Mataka, L., & Shekoyan, V. (2021). Using PhET simulations to improve scientific skills and attitudes of community college students. *International Journal of Education in Mathematics, Science, and Technology*, 9(3), 353-370
21. Wieman, C. E., Adams, W. K., Loeblein, P., & Perkins, K. K. (2010). Teaching physics using PhET simulations. *The Physics Teacher*, 48(4), 225-227.