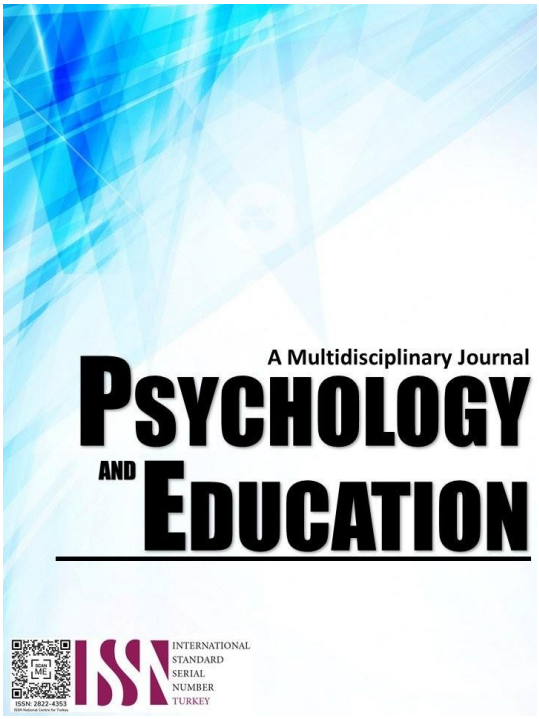
EFFECTIVENESS OF SIMULATION STRATEGY IN TEACHING SELECTED TOPICS IN BIOLOGY AT ASSUMPTION COLLEGE THONBURI, BANGKOK, THAILAND



PSYCHOLOGY AND EDUCATION: A MULTIDISCIPLINARY JOURNAL

Volume: 20
Issue 7
Pages: 825-837
Document ID: 2024PEMJ1897
DOI: 10.5281/zenodo.11548030
Manuscript Accepted: 05-15-2024

Psych Educ, 2024, **20**(7): 825-837, Document ID:2024PEMJ1897, doi:10.5281/zenodo.11548030, ISSN 2822-4353

Research Article

Effectiveness of Simulation Strategy in Teaching Selected Topics in Biology at Assumption College Thonburi, Bangkok, Thailand

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Abstract

Teaching biology in high school is challenging, with numerous topics to cover and potential pitfalls to avoid. Traditional teaching methods, like using textbook pictures, can be ineffective, especially when teaching complex concepts like evolution, genetics, and kingdoms of classification. To address this, educators are turning to simulations to improve the teaching and learning process. Simulations have been used in various fields for decades, allowing scientists to model and communicate complex ideas effectively. Not surprisingly, science students also benefit from using simulations to enhance their understanding and knowledge integration. A study in Bangkok, Thailand, investigated the effectiveness of using simulations to teach selected topics in biology to Grade 12 students. The research compared a traditional lecture-based approach with a simulation-based method using an interactive computer simulation called PLIX. Results showed that students in the simulation-based group had significantly higher post-test scores than those in the traditional teaching group. This suggests that incorporating simulations into biology lessons can enhance students' understanding of complex scientific concepts. Educators are encouraged to integrate simulation-based teaching methods into their curricula to improve student learning and engagement in science education.

Keywords: *simulation strategy, lecture-based approach, biology*

Introduction

Biology is the scientific study of living organisms and their interactions with their surroundings. It spans a wide range of disciplines, from the study of tiny organisms to the complexity of ecosystems, and from the inner workings of cells to the huge diversity of animals that populate our world. It was the core of learning and teaching biology. Despite its importance, evolution teaching continues to face a number of persistent obstacles, including conceptual understanding, acceptability, and perceived relevance of evolutionary theory by general education students (Hanisch & Eirdosh, 2020).

Genetics in biology is the scientific study of genes, heredity, and how certain qualities or traits are passed from parents to offspring as a result of changes in DNA sequence. Genetics helps explain what makes every individual unique or one-of-a-kind, why family members look alike, or even why some diseases like diabetes or cancer run in families.

Evolution is a process that results in changes in the genetic material of a population over time. Evolution represents the adaptations of organisms to their changing environments and can result in altered genes, unique features, and new species.

The domain of classification of an organism often provides useful information about its evolutionary history and which other organisms are related to it. It helps ascertain the number of living beings on Earth. It aims to classify living organisms. Millions of organisms are classified scientifically into categories, which helps to have a better understanding.

There are numerous grounds for declining evolution, and they differ in general and human evolution in particular. Many people, for example, have difficulties believing the process of evolution because of misconceptions about the idea itself (Talbot et al., 2020).

Despite clear indications in numerous literatures that evolution is a fundamentally relevant topic of Biology, it was not given sufficient focus in the curriculum, particularly in the Philippines. In the Senior High School curriculum of the Philippines, evolution received minimal emphasis and was unfortunately limited to STEM. The majority of evolutionary theory research is concerned with students' beliefs and conceptions, as well as their conceptual grasp. Even now, it is uncertain if evolutionary theory is getting the attention it deserves (Peregrino et al., 2022).

According to Peregrino et al., there is a need to motivate students about learning evolution in the Philippine education. They added the importance of developing a school climate that respects the theological and cultural debates around evolution which might help students obtain a better understanding of the subject.

The theory of evolution is one of the most complex concepts to understand but is essential for a complete understanding in Biology. However, students frequently fail to grasp its fundamental principles. Natural Selection is a fundamental concept taught at all school levels. Students in the third grade are first introduced to Natural Selection as they investigate inheritance, variation, and diversity of features (Thomas & Vo, 2021). Nevertheless, some pupils may lack a fundamental comprehension of it. This is mainly due to ineffective instruction; however, interactive activities could mitigate this issue.

Added to the conflicting theologies and religious principles, evolution is challenging to teach due to its complexity and controversy. However, despite these shenanigans, evolution is an integral part of biology and science curriculum in general, even cited by the

National Association of Biology Teachers (NABT) in the decision against the call of creationists in the case of John Freshwater in 2011, a grade 8 teacher in Mount Vernon, Ohio, who controversially taught the evidence for and against evolution (Branch & Reid, 2022).

According to the study conducted by Suwimon Tomaimoon and Runglawan Sudrudruk in 2019, the hardest topics in Biology for Thai students in Thailand include Genetics, Evolution, and Cell Biology. These topics were found to be challenging due to their complexity and abstract nature, as well as the lack of effective teaching methods. Students often struggle to understand the underlying concepts and theories, leading to poor performance in examinations.

Another study by Jirapat Wongsirisuit in 2015 identified Molecular Biology as one of the difficult topics for Thai students in Biology. This topic involves the study of the structure and function of biological molecules such as DNA, RNA and proteins, which can be challenging for students to grasp.

Furthermore, a survey conducted by Prakit in 2017 revealed that Ecology and Environmental Biology are also considered difficult topics by Thai students. These topics involve studying interactions between organisms and their environment, as well as conservation and sustainability issues, which can be complex and overwhelming for students.

Using simulators as teaching aids promotes student involvement and appears to aid in comprehending challenging subjects. They can be an alternative to practical or experimental methods in natural science classes when the needed time and space scales are inconsistent with the scholarly environment. Using interactive simulators, students can investigate the topic being studied. With further simulations, discoveries are made, and predictions are validated or denied, expanding our understanding of the phenomenon (Caetano et al., 2020).

Without simulation or any other modeling means, teaching the concept of biology is hard to imagine, and most of the time, the task becomes impossible. Especially with the creation of STEM (Science, Technology, Engineering, and Mathematics) in high school, the demand for educators to have reliable and effective teaching techniques in delivering science lessons becomes even more (Ruparanganda, 2019).

Simulations have become increasingly popular in teaching various secondary education subjects, including evolution theory. Evolution theory is a complex and often a controversial subject that has traditionally been taught using lectures, textbooks, and diagrams. However, using virtual simulations can provide students with a more interactive and engaging way to learn about the concepts and processes involved in evolution theory (Bogusevschi et al., 2020)

Additionally, virtual simulations (also called computer simulations) should ideally be adaptable, dynamic, and interactive to promote inquiry-based exploration, in which students draw their own conclusions about scientific concepts and ideas by modifying the values of different variables and observing their own effects. According to Alain Gholam (2019), science cognition and learning are enhanced when students can interact with their surroundings and participate in inquiry-based science interventions.

Using simulations as teaching aids is becoming increasingly popular in secondary education as they provide an interactive and engaging way for students to learn complex and challenging subjects such as evolution theory. The benefits of using virtual simulations in teaching include promoting student involvement, aiding comprehension, and enabling inquiry - based exploration. Using simulations can also provide an alternative to practical or experimental methods when the necessary time and space scales are inconsistent with the scholarly environment. As Science Technology Engineering and Mathematics (STEM) strand education continues to grow, educators need reliable and effective teaching techniques to deliver science lessons, making simulations a valuable tool in modern pedagogy.

The belief that using simulation in teaching can enhance the student's skills development as well as their conceptual knowledge of science drove the desire to investigate on this strategy. Using simulation as a strategy can help teachers in teaching complex biology lessons like Genetics, Evolution, and the Kingdom of Classifications. With such a strategy, a simulation instructional material shall be crafted for teaching identified biology lessons.

Research Questions

The study aims to find out the effectiveness of using simulation in teaching selected topics in Biology at Assumption College Thonburi, Bangkok, Thailand. Specifically, it aims to answer the following research questions:

1. What is the level of mastery of Grade 12 students at Assumption College Thonburi, Bangkok, Thailand in the selected topics in Biology before the simulation?
2. What is the level of mastery of Grade 12 students at Assumption College Thonburi, Bangkok, Thailand in the selected topics in Biology after the simulation?
3. Is there a significant difference in the mastery of the selected topics in biology of the Grade12 students of Assumption College Thonburi, Bangkok, Thailand, before and after using the simulation?
4. Is the simulation effective or not in improving the mastery of selected topics in biology by the Grade 12 students at Assumption College Thonburi?
5. What intervention program could be offered by the researcher based on the findings of the study to further improve the learners' understanding of the selected topics in biology?

Methodology

Research Design

This research utilized an experimental type of research using pre- and post-tests to measure the effectiveness of simulation.

This explores the efficacy of utilizing virtual simulations in teaching biology. This method was chosen to investigate the cause-and-effect relationship between the independent variable (use of virtual simulations) and the dependent variable (improvement in learning outcomes).

The study involved a controlled environment where two groups were formed: a control group and an experimental group. The control group received traditional instruction without the use of virtual simulations, while the experimental group was exposed to the same lesson but with the incorporation of virtual simulations as a supplemental teaching tool.

To measure the impact of the intervention, the researcher assessed both groups by comparing their knowledge and understanding before and after the exposure to the different teaching methods. Pre-tests were conducted to establish a baseline of the participants' knowledge of biology. Then, the experimental group engaged with genetics lessons complemented by virtual simulations, while the control group received traditional teaching without this additional tool.

Participants

The research population for this study is the 50 Grade 12 students at Assumption College Thonburi, Bangkok, Thailand. The students are enrolled in the Intensive English Program Department for the school year 2023-2024 and have only been taught about evolution, kingdom of classifications and genetics once in their lives as students.

The study selected its participants using a specific sampling method known as purposive sampling. The purposive sampling method allowed for the deliberate selection of participants meeting these specific criteria, ensuring the study focused on students with a particular level of exposure to the subject matter, which aligned with the research objectives.

Instruments

The pre-test and post-test assessments consisting of 30 multiple-choice questions covering the same content were the main instruments and were administered to both groups. The questions were based on the learning objectives for teaching genetics, evolution, and the kingdom of classifications, and they were designed to measure the student's knowledge and understanding of the topics. Subject matter experts reviewed and validated the questions to ensure they are appropriate for the target population and would measure the intended learning outcomes. The pre-test and post-test scores were used as the data analyzed to determine the effectiveness of the simulation as a strategy in teaching biology topics.

A survey questionnaire was also used as a research instrument to determine the participants' perceptions of the simulation-based teaching method compared to traditional teaching methods, the participants' attitudes toward evolution, and their interest in learning more about the topic.

Procedure

A systematic approach to ensure the validity and reliability of the data collected was applied. This included a series of meetings with participants and their parents, obtaining parental consent, administering pre-tests and post-tests, and conducting a survey for feedback.

Firstly, a series of meetings was held with the participants to explain the study and obtain their informed consent. During the meetings, the purpose of the study, the procedures involved, and the potential risks and benefits of becoming a respondent were explained. Participants were also encouraged to ask any questions they may have about the study.

Secondly, the participants' parents were informed about the study via parental consent. Parents received a consent form outlining the study's purpose, procedures, and potential risks and benefits of their children's participation. The consent form included information about the rights of the participants and their data privacy rights.

Thirdly, pre-test and post-test assessments were conducted to measure the effectiveness of the simulation-based teaching method compared to traditional teaching methods. The pre-test assessment was administered before the intervention, while the post- test assessment was administered after the intervention. The results of the assessments will be were exclusively kept and used solely for the study, ensuring the participants' rights for Data Privacy Act.

Finally, the participants were given a survey questionnaire to obtain feedback and personal opinions about their experience. The survey was used to gather information about the participants' perceptions of the simulation-based teaching method and how it compared to traditional teaching methods. The survey also included questions about the participants' attitudes toward evolution and their interest in learning more about the topic.

Data Analysis

The t-test was used to determine the significant difference between the pre-test and post-test of the Control and Experimental group. The t-test is essential to determine if the results obtained from a sample can be generalized to the population. The t-test enables researchers to determine if the difference between the means of two groups is due to chance or if it is statistically significant.

In conducting the t-test, the mean and standard deviation of the pre-test and post-test scores within each group and against the other group were determined. Then the means were compared using the t-test to determine if their difference was statistically significant.

The score will be determined using the Likert scale.

Numerical Scale	*Weighted Mean Interval Scale*	*Mean Descriptive Equivalent*
1-6	1.00–6.80	Very Low
7-11	6.81– 12.60	Low
12–17	12.61–18.40	Moderate
18-23	18.41–24.20	High
24-30	24.21–30.00	Very High

Results and Discussion

The presentation, analysis, and interpretation of data gathered during the investigation into the Effectiveness of Simulation Strategy in teaching selected topics in Biology at Assumption College Thonburi, Bangkok, Thailand, are covered in this chapter.

The information gathered is an essential tool for assessing how well simulation-based instructional techniques have been effective in helping Grade 12 students better understand selected topics in Biology.

The presentations of data are organized by showing the core from the pre and post-tests given to both the control and experimental groups. Prior to the educational intervention, the pre-test results will give an basic understanding of the students' familiarity with genetics, evolution and kingdom of classification principles, and the post test findings will show how simulation-based training significant to the students' understanding of the subject.

The following are the pre-test of both groups, which are treated using the t-test to find out their significant.

Level of Mastery of Grade 12 students at Assumption College Thonburi, Bangkok, Thailand in the selected topics in Biology before the simulation

Table 1. *Frequency and Percentage Distribution Showing the Level of Mastery of Grade 12 Students (Pretest Results) at Assumption College Thonburi, Bangkok, Thailand in the Selected Topics in Biology without Simulation (Control Group)*

Percentage of Marks	*Level of Mastery*	*Frequency*	*Percentage (%)*
91 and above	Outstanding	0	0.00
81 to 90	Excellent	0	0.00
71 to 80	Very Good	2	8.00
61 to 70	Good	7	28.00
51 to 60	Fair	4	16.00
41 to 50	Below Average	1	4.00
Below 40	Failed/Not Responded	11	44.00
	Total	25	100.00
Mean		15.12	
SD		6.08	

Table 1 illustrates the distribution of Grade 12 students' pretest scores in a selected biology topic without simulation at Assumption College Thonburi, Bangkok. It is evident that a substantial number of students, 44%, fell into the "Failed/Not Responded" category, while no students achieved "Outstanding" or "Excellent" scores. The average score of 15.12 implies overall poor performance, and the relatively high standard deviation of 6.08 indicates significant variability in the scores. These findings points out a need for further investigation into the factors affecting student performance and the implementation of targeted interventions to improve outcomes in this specific subject.

Table 2 provides a breakdown of Grade 12 students' pretest scores in the selected topic using simulation at Assumption College Thonburi in Bangkok, Thailand (Experimental Group). The data indicates that none of the students achieved "Outstanding" or "Excellent" scores, which is notable. Instead, the majority of students scored in the "Good" to "Failed/Not Responded" range, with 24% falling into the latter category. The mean score remains at 15.12, similar to the Control Group, but the standard deviation is lower at 4.85, suggesting somewhat less variability in scores. While there is still room for improvement, the simulation approach appears to yield slightly better results compared to the non-simulation approach, as indicated by the lower percentage of students in the "Failed/Not Responded" category.

Table 2. *Frequency and Percentage Distribution of the Respondents Showing the Level of Mastery of Grade 12 students (Pretest) at Assumption College Thonburi, Bangkok, Thailand in the Selected Topics Using Simulation (Experimental Group)*

Percentage of Marks	*Level of Mastery*	*Frequency*	*Percentage (%)*
91 and above	Outstanding	0	0.00
81 to 90	Excellent	0	0.00
71 to 80	Very Good	2	8.00
61 to 70	Good	5	20.00
51 to 60	Fair	5	20.00
41 to 50	Below Average	7	28.00
Below 40	Failed/Not Responded	6	24.00
	Total	25	100.00
	Mean		15.12
	SD		4.85

Table 3. *Pre-test Results of the Controlled Group and Experimental Group*

Student	*Controlled Group*	*Experimental Group*
1	17	8
2	12	21
3	21	19
4	20	14
5	19	15
6	10	12
7	9	10
8	18	13
9	9	4
10	7	13
11	25	20
12	10	7
13	21	12
14	4	14
15	7	16
16	20	18
17	12	19
18	9	17
19	21	23
20	20	16
21	17	23
22	26	13
23	15	13
24	18	18
25	11	20

The pre-test scores from both the Controlled Group and the Experimental Group provide useful information about the students' prior knowledge. It's clear that the Controlled Group had higher starting scores on average than the Experimental Group. This mismatch may indicate that students in the Control Group were more familiar with or exposed to the subject matter than those in the Experimental Group. Several students in the Control Group, for example, scored far higher than their peers in the Experimental Group. Student 11 in the Controlled Group received a score of 25, whereas the comparable student in the Experimental Group had a score of 20. This pattern was observed across several students, showing a continuous difference in prior knowledge between the groups.

The disparities in pre-test scores between the two groups could indicate variances in their readiness for the impending course topic. It is critical to understand how these disparities may affect their learning results throughout the course. Students with higher pre-test results, for example, may have a fundamental understanding that may help them grasp more complicated topics or concepts given in the course. Those with lower initial scores, on the other hand, may encounter a steeper learning curve or require additional assistance to overcome the knowledge gap. Understanding these differences and their impact on subsequent learning outcomes can be critical in adjusting teaching strategies to fit varying degrees of prior knowledge.

Table 4 shows the statistical treatment of the two groups. Since the computed t-value is 0.3149, which is lower than the expected p-value of 1.771, we can say that there is no significant difference between the pre-tests of the two groups.

The results of this study suggest that pretesting, or taking a test before learning, can be effective for improving the learning of the specific information included on the pretest but that it may not be effective in ensuring the learning outcomes of other information not included on the pretest. The pretesting effect is a phenomenon that occurs when people take tests before learning and increases the long-term retention of the information that was tested (James & Storm, 2019).

Table 4. *Statistical Treatment of the Group's Pre-Test*

Group	*Group 1*	*Group 2*	*t-value*	*df*	*Standard Error of Difference*
Mean	15.52	15.12	0.3149	24	1.27
SD	5.99	4.85			
SEM	1.2	0.97			
N	25	25			

Level of Mastery of Grade 12 students at Assumption College Thonburi, Bangkok, Thailand in the selected topics in Biology after the simulation

Table 5. *Frequency and Percentage Distribution Showing the Level of Mastery of Grade 12 Students (Posttest) at Assumption College Thonburi, Bangkok, Thailand in the Selected Topics in Biology at the end of the Lesson without Simulation (Control Group)*

Percentage of Marks	*Level of Mastery*	*Frequency*	*Percentage (%)*
91 and above	Outstanding	3	12.00
81 to 90	Excellent	5	20.00
71 to 80	Very Good	2	8.00
61 to 70	Good	2	8.00
51 to 60	Fair	2	8.00
41 to 50	Below Average	5	20.00
Below 40	Failed/Not Responded	6	24.00
	Total	25	100.00
	Mean	18.88	
	SD	7.11	

Table 5 presents the distribution of Grade 12 students' post-test scores in the selected biology topic at Assumption College Thonburi, Bangkok, Thailand, at the end of the lesson without simulation (Control Group). Unlike the pretest results, in the posttest, a notable improvement is observed in student performance. The majority of students now fall into the "Excellent" and "Outstanding" categories, with 32% achieving these high scores. The mean score has also increased to 18.88, indicating overall improved performance. However, there is still a relatively high standard deviation of 7.11, suggesting some variability in scores. This improvement in performance between the pretest and posttest could reflect the effectiveness of the teaching method used during the course.

Table 6. *Pre-Test and Post-Test Scores of Controlled Group*

Student	*Pretest Score*	*Posttest Score*
1	17	17
2	12	11
3	21	27
4	20	26
5	19	26
6	10	26
7	9	12
8	18	23
9	9	13
10	7	19
11	25	20
12	10	14
13	21	18
14	4	10
15	7	15
16	20	25
17	12	12
18	9	7
19	21	30
20	20	30
21	17	23
22	26	29
23	15	10
24	18	15
25	11	14

The Pre-Test and Post-Test scores from the Controlled Group provide an interesting glimpse into the students' improvement over the course time. When the Pre-Test and Post-Test scores are compared, it is clear that some students maintained their scores from the Pre-Test to the Post-Test. Students 1, 11, 13, and 21, for example, kept similar scores from their Pre-Test to their Post-Test. This constancy in scores could imply that students retained a solid comprehension of the material throughout the course.

In contrast, several students showed a significant improvement in their Post-Test scores compared to their Pre-Test scores. Students in grades 3, 4, 5, 6, 16, 19, 20, and 22 significantly improved their results from the Pre-Test to the Post-Test, with some earning a perfect score of 30. This improvement could be attributed to a variety of factors, including a greater knowledge of the course subject, more in-depth understanding, or successful teaching strategies used during the course. The pupils' improved performance from the Pre-Test to the Post-Test demonstrates a positive learning outcome and remarkable degree of improvement.

However, it's worth noting that some students' Post-Test scores were lower than their Pre-Test scores. Students 2, 8, 9, 12, 14, 15, 17, 18, 23, and 25 saw a drop in their results. The causes for this reduction could range from test anxiety to misinterpretation of post-test content to a lack of understanding of certain topics addressed in the course. These examples indicate the need for a more in-depth review of the teaching techniques or areas of the curriculum that may require reinforcement or further attention to assist these pupils in enhancing their knowledge.

Table 7. *Mastery of Selected Topics in Biology by the Grade 12 students (Control Group) at Assumption College Thonburi without Simulation (Pre-test and Post-test)*

Percentage of Marks	*Competency Level*	*Frequency (Pretest)*	*Percentage (%)*	*Frequency (Post-test)*	*Percentage (%)*	*Gain (Effectiveness)*
91 and above	Outstanding	0	0.00	3	12.00	+3
81 to 90	Excellent	0	0.00	5	20.00	+5
71 to 80	Very Good	2	8.00	2	8.00	0
61 to 70	Good	7	28.00	2	8.00	-5
51 to 60	Fair	4	16.00	2	8.00	-2
41 to 50	Below Average	1	4.00	5	20.00	+4
Below 40	Failed/Not Responded	11	44.00	6	24.00	-5
	Total	25	100.00	25	100.00	
	SD		15.12		18.88	
	Mean		6.08		7.11	

The data in Table 7 suggests that the simulation had a positive impact on the competency levels of Grade 12 students in the control group at Assumption College Thonburi. The increase in the "Excellent" and "Outstanding" categories indicates the effectiveness of the simulation in enhancing student performance. However, there were also students who experienced a decrease in competency, especially in the "Good" category, which suggest for a closer examination of the simulation's effectiveness for different student groups. Overall, the data highlights the potential benefits of educational interventions such as simulations in improving student outcomes.

Table 8. *Statistical Treatment of the Pretest and Posttest of the Controlled Group*

Controlled Group	*Pre-Test*	*Post-Test*	*t-value*	*df*	*Standard Error of Difference*
Mean	15.52	18.88	3.5673	24	1.054
SD	6.08	7.11			
SEM	1.2	1.42			
N	25	25			

Table 8 shows the statistical treatment of the Controlled Group's pretest and posttest. The t-value read as 3.5673. Since it is higher than the expected p-value of 1.771, it reveals a significant difference in the result of the pretest and posttest of the Controlled Group.

The results therefore agree with a study that traditional teaching still dominates Mathematics and Sciences. According to Schwerdt and Wuppermann (2011), traditional method such as lecture style of teaching can still contribute significantly to learner's achievement rate. The study also reminded that there is minimal chance of improving overall achievement levels by merely switching the teaching approach from lecture-style presentation to problem-solving without considering how the methods are put into practice.

Contrary to this, the majority of traditional teaching methods are teacher-directed and designed to encourage students to sit still and listen. As seen by the past successes of many, it is true that the traditional expectations and departmental philosophies frequently permit us to keep using the lecture-based approach with some beneficial effects. This cannot be denied as much. However, it is frequently argued that the traditional method may not give students useful skills, and some even claim that it prevents students from remembering information after exams – they have little to no recall of the body of knowledge they have learned after the end of a semester, for instance (Tularam, 2018).

The data suggests that the simulation had a positive impact on the competency levels of Grade 12 students in the selected topics in Biology. A significant portion of students achieved high levels of mastery, with "Outstanding" and "Excellent" being the most common categories. The mean competency level is relatively high, reflecting the overall effectiveness of the simulation in enhancing student performance. However, it's worth noting that there are still students in the "Good," "Fair," and "Failed/Not Responded" categories, indicating some variability in outcomes that needs to be reviewed.

Table 9. *Frequency and Percentage Distribution Showing the Level of Mastery of Grade 12 Students (Posttest) at Assumption College Thonburi, Bangkok, Thailand in the Selected Topics in Biology after the Simulation (Experimental Group)*

Percentage of Marks	*Level of Mastery*	*Frequency*	*Percentage (%)*
91 and above	Outstanding	7	28.00
81 to 90	Excellent	5	20.00
71 to 80	Very Good	6	24.00
61 to 70	Good	3	12.00
51 to 60	Fair	1	4.00
41 to 50	Below Average	0	0.00
Below 40	Failed/Not Responded	3	12.00
	Total	25	100.00
	Mean	23.16	
	SD	6.69	

Significant difference in the mastery of the selected topics in Biology of the Grade 12 students at Assumption College Thonburi, Bangkok, Thailand before and after using the simulation

Table 10. *Pretest and Posttest Scores of the Experimental Group*

Student	*Pretest Score*	*Posttest Score*
1	8	24
2	21	27
3	19	30
4	14	28
5	15	24
6	12	19
7	10	10
8	13	27
9	4	6
10	13	26
11	20	24
12	7	8
13	12	22
14	14	21
15	16	25
16	18	23
17	19	18
18	17	29
19	23	29
20	16	20
21	23	30
22	13	26
23	13	24
24	18	29
25	20	30

A significant number of students in the Experimental Group showed significant improvement from their Pretest to Posttest scores. Students 1, 2, 3, 4, 5, 8, 10, 11, 13, 14, 15, 16, 18, 19, 21, 22, 24, and 25 significantly improved their results. Several students received maximum Posttest scores of 30, demonstrating a thorough knowledge and memory of the subject covered. These enhancements could be attributed to a better understanding of the course content, more effective teaching methods, or a deeper understanding of the topics during the course period. The remarkable progress demonstrated by the majority of students in the Experimental Group shows a positive learning outcome.

It is crucial to note, however, that some students in the Experimental Group had lower Posttest scores compared to their Pretest levels. Students 6, 7, 9, 12, 17, and 20 had lower Posttest scores. The causes for this drop could range from potential difficulty or feeling of discomfort in the simulation.

The presence of both a significant boost and reductions in scores within the Experimental Group demonstrates the students' diverse learning outcomes. While many students made significant progress, some had difficulties or performed poorly on the Posttest.

Table 11 provides data on the effectiveness of the simulation in enhancing the mastery of selected biology topics for Grade 12 students at Assumption College Thonburi. The posttest results indicate a substantial improvement, with the number of students in the 'Outstanding' and 'Excellent' categories increasing by 7 and 5, respectively. The 'Very Good' category also saw an improvement of 4

students. However, there was a decline in the 'Good,' 'Fair,' and 'Below Average' categories, with losses of 2, 4, and 7 students, respectively.

Table 11. *Effectiveness of the Simulation in Improving the Mastery of Selected Topics in Biology by the Grade 12 Students at Assumption College Thonburi with Simulation (Experimental Group)*

Percentage of Marks	*Competency Level*	*Frequency (Pretest)*	*Percentage (%)*	*Frequency (Post-test)*	*Percentage (%)*	*Gain (Effectiveness)*
91 and above	Outstanding	0	0.00	7	28.00	+7
81 to 90	Excellent	0	0.00	5	20.00	+5
71 to 80	Very Good	2	8.00	6	24.00	+4
61 to 70	Good	5	20.00	3	12.00	-2
51 to 60	Fair	5	20.00	1	4.00	-4
41 to 50	Below Average	7	28.00	0	0.00	-7
Below 40	Failed/Not Responded	6	24.00	3	12.00	3
	Total	25	100.00	25	100.00	

This indicates that the simulation was particularly effective for high-achieving students but lesser so for those in the 'Good' to 'Below Average' range. The mean pretest score increased from an initial 20.88 to 22.16 in the posttest. While the simulation had an overall positive effect, it may need further refinement to cater to a broader range of students' needs and competencies.

Table 12. *Statistical Treatment of the Pretest and Posttest of the Experimental Group*

Controlled Group	*Pre-Test*	*Post-Test*	*t-value*	*df*	*Standard Error of Difference*
Mean	15.08	23.16	4.8884	48	1.653
SD	4.85	6.69			
SEM	0.97	1.34			
N	25	25			

Table 12 shows the statistical treatment of the Experimental Group's pretest and posttest. The t-value read as 4.8884 which is higher than the expected p-value of 1.771; hence, significant difference is manifested between the result of the pretest and posttest scores of the Experimental Group.

The result in the study about simulation technology of Morgan et al. (2002) agrees with the current study. The researchers (Morgan, et al.) confidently claimed that the posttest results' improvement was not unexpected and was a predictable result. Depending on the scenario that was learned and assessed, the results of the current study also showed a substantial difference between the pretest and posttest scores.

Another study congruent with the result is the study of Akinsola and Animasahun (2007) on using modeling environment. The findings of this study also suggest that using simulation-game environments has a good impact on students' attitudes. The experimental and control groups' academic accomplishment significantly differs from one another, and this encourages positive changes in people's attitudes and behaviors toward mathematics.

Is the simulation effective or not in improving the mastery of selected topics in Biology by the Grade 12 students at Assumption College Thonburi?

Table 13 shows the side-by-side comparison of the posttests results of the Controlled (traditional) and Experimental (simulation) group. Looking at the results, it is clear that the Experimental Group has greater Posttest scores than the Controlled Group. For instance, students in the Experimental Group consistently achieved higher scores in the Posttest than their counterparts in the Controlled Group. Students 1, 2, 3, 4, 5, 6, 8, 10, 11, 13, 15, 16, 19, 21, 22, 24, and 25 in the Experimental Group outperformed their counterparts in the Controlled Group. This continuous pattern shows that the inclusion of virtual simulations may have positively benefited the Experimental Group's learning outcomes.

In contrast, several students in the Controlled Group achieved better Posttest scores than their colleagues in the Experimental Group. Students 7, 9, 12, 14, 17, 18, and 20 from the Controlled Group performed better on the Posttest than students from the Experimental Group. This suggests that a fraction of students in the Controlled Group may prefer traditional teaching approaches to the usage of virtual simulations.

The Posttest Results show a general tendency of higher scores in the Experimental Group, implying that the incorporation of virtual simulations may have influenced learning outcomes positively. However, some students in the Controlled Group scored higher, demonstrating that different teaching methods may have distinct individual responses, underlining the necessity for individualized and adaptive educational approaches to respond to unique learning demands.

Table 13. *Posttest Results of the Controlled Group and Experimental Group*

Student	*Controlled Group*	*Experimental Group*
1	17	24
2	11	27
3	27	30
4	26	28
5	26	24
6	26	19
7	12	10
8	23	27
9	13	6
10	19	26
11	20	24
12	14	8
13	18	22
14	10	21
15	15	25
16	25	23
17	12	18
18	7	29
19	30	29
20	30	20
21	23	30
22	29	26
23	10	24
24	15	29
25	14	30

Table 14. *Statistical Treatment of the Posttests of the Controlled Group and Experimental Group*

Controlled Group	*Pre-Test*	*Post-Test*	*t-value*	*df*	*Standard Error of Difference*
Mean	18.88	23.16	2.1918	48	1.953
SD	7.11	6.69			
SEM	1.42	1.34			
N	25	25			

Table 14 shows the statistical treatment of the two groups using t-test. The results for both groups as shown in previous tables have revealed significant differences between their respective pretests and posttests. When compared to each other, the two posttests show significant differences since the t-value of 2.1918 is higher than the expected p-value of 1.771.

Using the result, this study therefore corresponds with other studies that used simulations over traditional teaching methods. This study also settles that simulations are highly recommended in teaching difficult topics in Biology such as Evolution, Genetics and Kingdom of Classifications.

Table 15. *One-Way ANOVA: Comparison in the Mastery of the Selected Topics in Biology of the Grade 12 students of Assumption College Thonburi, Bangkok, Thailand*

Indicator	*Test Scores*	*Mean*	*f value*	*p-value*	*Decision*	*Remarks*
Traditional Group	Pre-Test	15.12	4.0407	0.051	Failed to Reject Ho	Not Significant
	Post-Test	18.88				
Simulation Group	Pre-Test	15.12	23.6494	0.000	Reject Ho	Significant
	Post-Test	23.16				

Note: "If p value is less than or equal to the level of significance (0.05) reject Ho, otherwise failed to reject Ho."

Table 15 presents the results of a one-way ANOVA analysis comparing the mastery of selected biology topics for Grade 12 students at Assumption College Thonburi in the traditional group and the simulation group. For the traditional group, the pre-test and post-test means are 15.12 and 18.88, respectively, with an F-value of 4.0407 and a p-value of 0.051. In this case, the p-value is greater than the significance level (0.05), leading to a decision of "Failed to Reject Ho," indicating that there is no statistically significant difference between the pre-test and post-test scores for the traditional group.

Conversely, for the simulation group, the pre-test and post-test means are 15.12 and 23.16, with an F-value of 23.6494 and a p-value of 0.000. The p-value is less than the significance level, leading to a decision to "Reject Ho," signifying a significant difference between the pre-test and post-test scores for the simulation group. These results indicate that the simulation had a statistically significant impact on the mastery of selected biology topics for the Grade 12 students, suggesting that the simulation was effective in improving their performance.

Intervention program that could be offered by the researcher based on the findings of the study to further improve the learner's understanding of the selected topics in Biology

Based on the findings of the study, the researcher could offer an intervention program to further improve the learners' understanding of the selected topics in biology. Here is an example of an intervention program:

Title: Biology Enrichment Program: Exploring Concepts Beyond the Classroom

Objective: The objective of this intervention program is to deepen learners' understanding of the selected biology topics and foster a passion for the subject through an engaging and interactive approach.

Components of the Intervention Program:

Hands-on activities and experiments: Design a series of hands-on activities and experiments that allow learners to directly engage with the biology concepts covered in the study. These activities should encourage critical thinking, problem-solving, and application of knowledge. Provide clear instructions, necessary resources, and guidance to ensure learners can successfully complete the activities.

Field trips and real-world connections: Organize educational field trips or visits to relevant institutions, such as nature reserves, botanical gardens, or research facilities, to provide learners with real-world contexts and experiences related to the biology topics. Engage learners in observations, data collection, and analysis during these visits, fostering a deeper connection between theory and practice.

Guest speakers and expert sessions: Invite guest speakers and subject matter experts to deliver interactive sessions on specific biology topics that align with the study's findings. These sessions should provide learners with expert insights, practical examples, and current research advancements. Encourage learners to ask questions and initiate discussions to enhance their understanding.

Technology integration and virtual resources: Leverage technology by incorporating virtual resources, such as online simulations, interactive websites, and educational videos, to complement the study findings. Provide learners with access to these resources and guide them on how to use them effectively to further explore and reinforce the biology concepts.

Collaborative projects and presentations: Assign collaborative projects that require learners to work in groups to investigate and present on specific biology topics. Encourage interdisciplinary approaches, where learners can blend their knowledge from other subjects, such as chemistry or environmental science, in understanding and solving complex biological problems. Allow learners to showcase their projects through presentations, exhibitions, or online platforms to enhance engagement and peer learning.

Progress assessments and feedback: Administer progress assessments throughout the intervention program to gauge learners' understanding and monitor their growth. Provide timely feedback to learners, highlighting their strengths and areas for improvement. Offer additional support and resources to address any identified gaps in understanding.

Reflection and metacognition: Incorporate reflective activities, such as journaling, group discussions, or reflective essays, where learners can analyze their learning experiences, understand their thought processes, and identify areas of personal growth and development. Encourage learners to think critically about the biology concepts, make connections to their everyday lives, and consider the implications of the study findings in broader contexts.

Community engagement and projects: Encourage learners to engage with the local community by developing projects that involve applying biology knowledge to address local environmental or health issues. This allows learners to see the relevance and impact of the biology concepts in their own community, fostering a sense of responsibility and active citizenship.

By implementing this intervention program, the researcher aims to provide learners with varied and enriching learning experiences that go beyond the traditional classroom setting. This approach can inspire curiosity, promote a deeper understanding of biology concepts, and nurture a lifelong love for the subject.

Conclusion

In conclusion, this research study titled "Effectiveness of Simulation Strategy in Teaching Selected Topics in Biology at Assumption College Thonburi, Bangkok, Thailand" aimed to investigate the effectiveness of using simulation as a teaching method for complex Biology subjects, specifically Kingdom of Classification, Genetics and Evolution theory, among Grade 12 students. The study findings provide valuable insights into the impact of simulation-based teaching on student performance when compared to traditional lecture-based teaching.

The result of the study led to the decision to reject the null hypothesis. The study initially found that there was no significant difference in the pre-test results between the controlled (traditional) group and the experimental group, indicating that both groups had a similar level of knowledge about the selected topics in Biology before the instruction began.

Notably, the pre-test and post-test results of the Controlled Group showed significant differences. This suggests that traditional teaching methods have a positive impact on student performance, reaffirming the value of conventional teaching approaches.

The Experimental Group, which received instruction using simulation-based teaching, exhibited significant differences between their pre-test and post-test results. This finding strongly aligns with existing research, indicating that simulation teaching positively influences student performance and understanding.

Most significantly, the post-test results of the two groups demonstrated a substantial difference, with the Experimental Group outperforming the Controlled Group. This outcome suggests that simulation teaching has a more pronounced impact on student performance in comparison to traditional lecture-based teaching methods.

Based on the study's findings, the following recommendations are made:

After a thorough study of this research, it shows that simulation is proven effective in teaching selected topics in biology. Educators may consider incorporating simulation-based teaching methods into their curriculum, particularly for complex subjects like evolution theory. This approach appears to enhance student understanding and performance.

A combination of traditional teaching methods and simulation-based teaching can be a powerful approach. Educators should explore a blended teaching strategy that utilizes both approaches to cater to the diverse learning needs of students.

Teachers may receive training and professional development opportunities to effectively integrate simulation-based teaching into their lessons. This ensures that they can make the most of this teaching method.

Educational institutions may encourage and support ongoing research and evaluation of teaching methods. This will help in the continuous improvement of instructional techniques, ensuring that students receive the best education possible.

Simulation-based teaching methods are more engaging for students. Therefore, educators may focus on designing interactive and immersive learning experiences to maintain student interest and motivation.

The findings of this study highlight the potential of simulation-based teaching in improving student performance and understanding of complex subjects like evolution theory. It is crucial for educational institutions and teachers to adapt and incorporate these effective teaching methods into their pedagogical strategies to enhance the quality of education and better prepare students for the challenges of the modern world.

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