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Enhancing secondary school students' attitudes toward physics by using computer simulations

Firas Tayseer Mohammad Ayasrah[a*], Khaleel Alarabi[a], Maitha Al mansouri[b], Hadya Abboud Abdel Fattah[c] and Khaleel Al-Said[d]

[a]*College of Education, Humanities and Science, Al Ain University, Al Ain, United Arab Emirates*
[b]*Department of Foundations of Education, United Arab Emirates university, United Arab Emirates*
[c]*Fatima College of Health Sciences, United Arab Emirates, Abu Dhabi, United Arab Emirates*
[d]*Department of Educational Technology, Middle East University, Amman, Jordan*

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ABSTRACT

Educational systems worldwide have witnessed a significant shift towards technological applications, especially after COVID-19, which impacted how the learning contents are delivered in classrooms. Given the increased attention given to the numerous advantages of computer Simulations (CSs) programs, particularly in science education, this study compared the efficacy of employing a lab simulation of Newton's Second Law of Motion to teach physics in the UAE secondary school environment versus the more conventional approach (Face-to-face instruction). The study employed a quasi-experimental design that included 90 UAE 11th-grade students from two public schools in the City of Al Ain. The intervention included student engagement in the PhET interactive simulation of Newton's second law of motion. The study employed the Test of Science-Related Attitudes (TOSRA) questionnaire to collect data before and after the intervention for the experimental and control groups. The findings demonstrated statistically significant differences between experimental and control groups in students' attitudes toward scientific inquiry, enjoyment of science lessons, and career interest in physics/science. Furthermore, results showed a significant difference in attitudes perceived in these scales, with males having a more significant effect size than female students in all three scales. The study concludes with implications and suggests recommendations for future research and practice.

1. Introduction

The twenty-first century has brought about a significant technological transformation that has profoundly impacted society, encompassing general and science education. Students must possess substantive knowledge and abilities to effectively navigate the dynamic landscape of technology and society and be ready to be good problem solvers with essential competencies. Therefore, the ever-changing student learning landscape must respond to such changes by moving away from the traditional instructional methods that exhibit minimal utilization of interactive participation and heavily rely on students sitting passively through lectures, performing assigned laboratory tasks, and conducting external observations (Hadzigeorgiou & Schulz, 2017; Hake, 1998; Cairns & Areepattamannil, 2019; Abu-AlSondos et al., 2023a).

* Corresponding author.
E-mail address: firas.ayasrah@aau.ac.ae (F. T. M. Ayasrah)

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In response to current education reform, innovative and interactive teaching and learning practices, such as computer simulations, have been introduced to impact student learning. When Computer Simulations (CSs) are used, it could allow students to conduct virtual experiments in which various factors are manipulated to obtain varying results (McDonald, 2016; Widiyatmoko, 2018). CSs virtual experiments enable students to model genuine systems or phenomena with multiple functions to examine different inputs, processes, and outputs, which is helpful in science education (Blake & Scanlon, 2007; De Jong & van Joolingen, 1998). In this sense, CSs have enormous potential to pique students' curiosity, enhance creativity and critical thinking, and encourage them to learn by doing. They allow students to experience and interact with natural events, challenge them, and provoke reactions (Council, 2011). Consequently, this allows CSs to tailor learning to each student's needs, pace, interests, and talents in an interactive virtual setting (Wieman et al., 2008; De Jong & Van Joolingen, 1998; Perkins et al., 2006). Furthermore, using CSs in teaching and learning has also impacted student interest and attitude toward science (Sari et al., 2019; Kattayat et al., 2016). For example, Sari et al. (2019) found that virtual apps and computer-based laboratories influence students' attitudes and motivations favorably. Other studies demonstrated that lab technology positively impacts student learning and attitudes (Aşıksoy & İşlek, 2017; Oymak & Ogan-Bekiroglu, 2017). Bozkurt and Ilik (2010) also discovered that CSs improved students' physics beliefs and achievement. According to Kattayat et al. (2016), when teachers adopt CSs based instruction in the classroom, students' favorable attitudes toward physics improve. Students can acquire higher results in physics because of this growth. Therefore, the significance of this study is the prospect of assisting physics teachers. The findings may provide an opportunity to approach physics teaching in more relevant ways and assist students in developing higher-level knowledge.

2. Problem Statement

Negative attitudes toward physics make learning difficult for many students (Sari et al., 2019; Erinosho, 2013). Erinosho (2013), for example, found that a student's attitude was one of three things that affected how well they learned physics. According to Balfakih (2003), UAE students had comparable issues with poor academic performance and unfavorable attitudes toward science, contributing to significant dropout rates for high school science students. There is a call to improve science teaching and learning due to students' low performance in Trends of the International Study of Mathematics and Science (TIMSS) (Wardat et al., 2022). This issue also calls for a study on the effectiveness of teaching approaches in science classrooms in UAE schools. This study is a response to previous calls for additional research on the efficiency of CSs in teaching physics (Batuyong & Antonio, 2018; Hadzigeorgiou & Schulz, 2017; Radlovic-Cubrilo et al., 2014). This study also addressed the knowledge gap regarding the efficacy of CSs on secondary school students' physics attitudes in the UAE, where no previous studies have examined the effect of CSs on attitudes toward physics.

3. Purpose of the Study

This study seeks to determine whether CSs could improve the attitudes of Emirati secondary school students toward physics. Specifically, the study intends to examine Grade 11 students' attitudes toward physics when taught in a CSs-based versus a non-CSs-based learning environment. To investigate how employing CSs could improve Emirati secondary school students' attitudes toward physics, the three research questions below are addressed by the study:

1- How do CSs affect grade 11 students’ attitudes toward physics?

2- Are there statistically significant differences in attitudes toward physics between CSs-based and non-CSs-based students learning?

3- How do CSs impact Grade 11 students’ attitudes toward physics based on gender?

4. Literature Review

Pyatt and Sims (2012) assert that attitudes toward specific learning environments and instructional approaches play a crucial role in learning. According to Eagle and Chaiken (1993), attitude is a psychological construct encompassing an individual's inclination toward expressing positive or negative sentiments toward an event, place, thing, or person. Gordon Allport once characterized attitudes as "the preeminent and essential construct in modern social psychology." (Definitions.net, 2020). Attitude is the tendency to rate one's attributes positively or negatively (Ajzen, 2001). In informal language, the attitude may refer to a particular mood concept or, more specifically, be synonymous with adolescent rebellion (Definitions.net, 2020; Wang, C et al ,2023) . Many definitions exist for attitudes toward science. George (2000) describes attitudes toward science as favorable or unfavorable views about science lessons.

The impact of interactive simulations on attitudes toward learning has been studied in recent years (Zacharia & Anderson, 2003). Using CSs can offer a valuable instrument to enhance students' attitudes and facilitate their academic accomplishments favorably. Kattayat et al. (2016) suggested integrating CSs into classroom learning to improve students' attitudes toward physics. This boost helps students perform better in physics. Sarı et al. (2017) found that interactive CSs used in scientific inquiry have a comparatively positive attitude toward physics compared to traditional teaching techniques. The study conducted by Abou Faour and Ayoubi (2017) demonstrates that the utilization of CSs significantly impacts students' attitudes and perceptions toward physics. Aşıksoy and İşlek (2017), on the other hand, noticed that CSs laboratory experience positively impacts students' attitudes toward physics. A study by Çetin (2018) showed that the effect of cooperative simulation-based learning on the students' attitudes toward physics is considerably more significant than that of traditional learning methods. Kattayat et al. (2016) found a considerable correlation between the physics accomplishments of adolescents exposed to simulation-assisted training and their attitude toward physics. Additionally, Sari et al. (2019) found that computer-based laboratories and virtual applications improved students' attitudes.

The literature also encompasses several elements that influence attitudes, such as the process of scientific inquiry, CSs laboratory experiments, simulation-based cooperative learning, and simulation-assisted instruction. Additionally, most studies have explored attitudes in general. However, there has been little discussion about the micro-levels of attitudes, Attitudes to Career Interest in Science (CIS), Enjoyment of Science Lessons (ESL), and Attitudes to Scientific Inquiry (ASI). The complexity of attitudes as a construct requires investigation at a micro-level, particularly regarding how students perceive science learning practices such as inquiry, future prospects of science-related careers, and enjoyment of science lessons. Early research on attitudes toward science showed how important it is to examine student attitudes toward distinctive and specific practices (Alghazzawi et al., 2022; Fraser, 1981). As such, the study reviewed attitudes at ASI, future CIS, and ESL levels.

5. Methodology

5.1 Research Setting and Sampling

The present study was conducted in two schools accredited by the Ministry of Education (MOE). One of the schools exclusively caters to male students and is staffed by male teachers, while the other school caters to female students and is staffed by female teachers. Both schools within a specific emirate in the UAE have adopted the curriculum provided by the MOE. The girls' school has 760 students in grades 9 through 12. Three classes of eleventh graders attended this school; one was chosen randomly to serve as the control group (CG) and the other as the experimental group (EG). The second boys' school has 870 ninth-through-12th-graders. The CG and EG of its four eleventh-grade classrooms are randomly selected.

All the classes exhibit similar demographic characteristics and adhere to the same school hours. In addition, during the 2019-2020 academic year, both classes were placed in the advanced stream. The sample for this study had a total of 90 participants, consisting of 50 males and 40 females. Table 1 highlights the study groups' characteristics. Before treatment, students were given TOSRA scales to examine their attitudes toward physics. PhET simulations were performed on EGs. After receiving the intervention, all students must complete the same questionnaire as a post-test.

Table 1
Groups of the Study

Study Groups	Gender	N	Total
EGs	Male	25	45
	Female	20	
CGs	Male	25	45
	Female	20	

5.2 Materials

The selection of NSLOM is based on its extensive applicability and significance as a subject matter that CSs must engage with. Interactive simulations from PhET are utilized as inquiry tools for students to enrich their theoretical comprehension of object motion and acceleration. These simulations provide a means to explore forces and computational motions, enhancing knowledge of these concepts (Adams et al., 2008). Students can use the simulation of force and motion to visualize the forces and events caused by motion and gain a deeper scientific understanding of force and motion. Students next conducted a series of experiments according to the NSLOM worksheet's predetermined instructions.

5.3 Research Design

This study used a quasi-experimental design with a pre-test, post-test, and control group. This design aims to demonstrate how the eleventh-grade students in the UAE who learn in environments based on CSs have different attitudes toward physics than students in the same grade who learn through non-CSs environments. The teaching method, which has two levels, is the main Independent Variable (IV): (1) A non-CSs-based learning environment (CG) and a CSs-based learning environment (EG). Students' scores on three scales of TOSRA developed by Fraser, 1981 served as the Dependent Variable (DV). ASI, CIS, and ESL were the selected measures.

5.4 Research Instrument

The effect of experimental treatment is evaluated using the three TOSRA scales. These scales were selected for the study based on their validity and reliability across various contexts (Smist et al., 1994; Fraser & Lee, 2015). According to Unfried et al. (2015), TOSRA demonstrates satisfactory internal consistency across its scales, with coefficients ranging from 0.64 to

0.93. Additionally, the instrument exhibits acceptable test-retest reliability. TOSRA was designed by Fraser (1981), who then broke it into component scales to examine secondary school students' attitudes on seven aspects of science. The ASI (10-item), ESL (10-item), and CIS (10-item) scales were selected and adapted from TOSRA because they were deemed most appropriate for the study's goals. The item distribution for the three scales is shown in Table 2. The TOSRA items assess students' pre- and post-test levels of attitudes toward physics by having them coordinate a response in which they indicate their level of agreement with each statement on a 5-point scale, ranging from Strong (high) degree of Agreement (SA) to Agree (A), Not sure (N), Disagree (D), and Strongly Disagree (SD).

Table 2
Item Distribution and Scoring Using the TOSRA Scale

	Scale		
	ASI	ESL	CIS
Items' Distribution	1, 4(-), 7, 10(-), 13, 16(-), 19, 22(-), 25, 28(-)	2, 5(-), 8, 11(-), 14, 17(-), 20, 23(-), 26, 29(-)	3(-), 6, 9(-), 12, 15(-), 18, 21(-), 24, 27(-), 30

For negative items (-), SA, A, NS, D, and SD are scored 1, 2, 3, 4, and 5, respectively.

A jury of experts in education, physics, and research reviewed and validated the scale once it was constructed. The experts provided comments and suggestions to the researchers. Most experts' and students' suggestions were considered in preparing the final version of the scale. Cronbach's Alpha was used to determine the reliability of the scale's constructs following validation, and the results are shown in Table 3. As illustrated in Table 3, The "ASI" scale has the lowest Cronbach's alpha value, at α = .720. However, "CIS" has the greatest Cronbach's alpha coefficient value (α = .759). Consequently, the reliability of the scores for the three scales was established. The coefficient alpha value of .90 indicates that the TOSRA scale used as an independent measure exhibited satisfactory reliability among the study participants. Therefore, it can be concluded that the internal consistency of this scale can be considered reliable.

Table 3
TOSRA Scale Reliability Coefficients Survey

Scales	N of Items	Mean (M)	Standard Deviation (SD)	Cronbach's Alpha (α)
CIS	10	23.60	6.777	.759
ASI	10	22.12	5.992	.720
ESL	10	22.93	6.647	.724
Total	30			.90

5.5 Data Collection Procedures

The Abu Dhabi Department of Education and Knowledge (ADEK) authorized the study in the UAE. The principals of the schools were contacted, and their agreement was gained. The data was collected in phases throughout a month, as shown in Fig. 1.

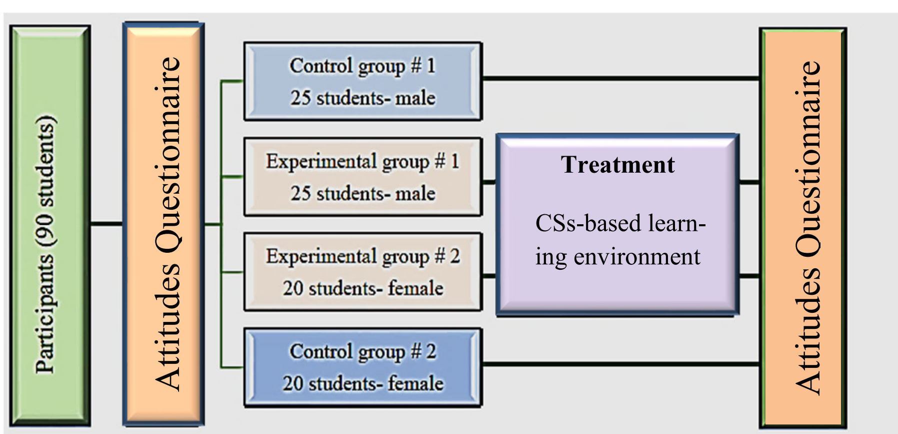

Fig. 1. Experimental Procedure of the Study

The students in this study had completed 20 sessions and three labs on NSLOM physics fundamentals. Students in CGs classes carried out conventional hands-on experiments on 'NSLOM.' Students in EGs, on the other hand, performed equivalent experiments utilizing a CSs-based learning environment. Finally, the survey was done in an environment of integrity to avoid unintended practices (Meyers et al., 2016; Creswell & Creswell, 2017).

6. Findings

6.1 Data Analysis

The data set's normality and equality of variance-covariance matrices satisfy the statistical assumptions needed to execute the analysis. Meyers et al. (2016) delineated several assumptions that must be met to appropriately employ Multivariate Analysis of Variance (MANOVA). First, the participants in this study are entirely independent of one another. The measurement types for ASI, ESL, and CIS are also continuous. Furthermore, the data are compatible with the assumption of a sufficient sample size. Box's Covariance Matrix Equality Test was performed. The study showed no significant differences at $p > .05$ (Box's M = 40.542, $p = .004 < .05$), demonstrating that the variance-covariance matrices of the dependent variable are not equal, supporting the homogeneity assumption. Bartlett's Test of Sphericity shows a significant correlation between the dependent measures (chi-square $\chi^2 = 219.784$, $p = .000 < .001$), allowing the analysis to proceed with the analysis. Finally, Data were split into two halves to check for outliers, and the linear regression of The Mahalanobis distance test was used to determine the data's crucial values. The critical value determined by Mahalanobis was lower than the critical value indicated by χ^2. Consequently, the data did not exhibit any extreme values or outliers. Therefore, the data satisfied the assumption of not containing any outliers. The study discovered that the assumptions had not been broken. Likewise, it was determined that the premises had not been violated regarding both genders.

6.2 Question One Results

The results of the independent sample t-test indicated that there was no statistically significant difference between the two groups in terms of their pre-test scores, with a significance level of $p < .05$, $t(88) = .122$, $p = .904$. As seen in Table 4, prior to the intervention process, the attitudes of EGs and CGs towards physics were similar.

Table 4
Independent Samples t-Test Pre-test Results for the Two Groups

Study groups	N	M	SD	t	df	Sig.
CGs	45	2.14	.59	.122	88	.904
EGs	45	2.16	.72			

Table 5 shows that the pre-test TOSRA scores for CGs and EGs were not statistically different ($p > .05$).

Table 5
Performance on the TOSRA Pre-test by the Two Groups

	Study groups	N	M	SD	t	df	Sig.
ASI	EGs	45	2.07	.722	-0.235	88	.815
	CGs	45	2.10	.61			
ESL	EGs	45	2.22	.74	0.182	88	.856
	CGs	45	2.20	.63			
CIS	EGs	45	2.19	.77	0.382	88	.703
	CGs	45	2.13	.65			

Under the assumption of equal variances, the subsequent test (independent sample t-test) found no statistically significant difference between the means ($t(88) = .189$, $p = .850$). As shown in Table 6, before the experiment, the male and female students' attitudes toward physics were comparable.

Table 6
Comparison of the Two Genders' Performance on the TOSRA Pre-test

Study groups	N	M	SD	t	df	Sig.
Female	40	2.14	.61	.189	88	.850
Male	50	2.17	.69			

Independent t-test performed after the intervention ended: $t(88) = 22.76$, $p = .000$. Table 7 shows that. As a result of the experiment, it can be claimed that the EGs' and CGs' attitudes toward physics are not the same after the experiment.

Table 7
Post-test Independent Samples t-Test Results for the Two Groups

Study groups	N	M	SD	t	df	Sig.
EGs	45	4.17	.18	22.76	88	.000
CGs	45	2.68	.39			

The results for each scale are presented in Table 8. The findings indicated statistically significant differences between the two groups across all scales. There were significant differences ($p = .000$) that favored the EGs in the areas of ASI, ESL, and CIS. In this scenario, it may be posited that CSs-based learning improves students' attitudes toward physics.

Table 8
Results of the Two Groups' Post-tests on the TOSRA Scales

	Study groups	N	M	SD	t	df	Sig.
ASI	EGs	45	4.01	.34	15.819	88	.000
	CGs	45	2.49	.54			
ESL	EGs	45	4.24	.33	17.169	88	.000
	CGs	45	2.72	.48			
CIS	EGs	45	4.26	.29	18.067	88	.000
	CGs	45	2.85	.43			

To compare the effect of CSs on each gender's attitude toward physics, effect sizes were calculated (see Table 9). CSs-based learning considerably improved the attitudes of both male and female students toward physics ($d > .80$).

Table 9
EGs' TOSRA Scale Attitude Gains by Gender

Scales		Pre-test		Post-test		Cohen's d*
		M	SD	M	SD	
ASI	Male	2.10	.72	3.20	.99	1.27
	Female	2.08	.59	3.31	.75	1.81
	Total	2.09	.66	3.25	.89	1.47
ESL	Male	2.23	.69	3.38	.93	1.40
	Female	2.19	.68	3.60	.77	1.92
	Total	2.21	.68	3.48	.86	1.62
CIS	Male	2.17	.75	3.47	.81	1.64
	Female	2.15	.66	3.66	.77	2.10
	Total	2.16	.71	3.55	.79	1.83

*: d = effect size

6.3 Question Two Results

MANOVA was used to address this question, with three scales (ASI, ESL, and CIS) as dependent variables and the instruction technique as an independent variable (CSs-based learning and non-CSs-based learning). The results of MANOVA, as presented in Table 10, revealed that the group variable had a statistically significant effect on attitudes across the three levels (Pillai's Trace = .871, $F(3, 84) = 188.776$, $p = .000 < .05$). The partial η2 effect size for the relationship under consideration is .871 for the tests. This implies notable differences in the three scales' attitudes toward various student groupings. Likewise, the findings of the MANOVA indicated that gender exerted a statistically significant impact on attitudes across the three levels, with $p < .05$ level (Pillai's Trace = .102, $F(3, 84) = 3.197$, $p = .028 < .05$). The partial relationship's effect size η2, was found to be .102 for tests. Hence, these findings indicate notable differences in attitudes across the three scales based on the gender of the students. In addition, the *group x Gender* multivariate interaction effect was statistically significant, with a Pillai's trace of .107, $F(3,84) = 3.357$, $p = .023 < .05$, and partial η2 of .107.

Table 10
Gender and Post-test Groups using Two-Way MANOVA

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared (η2)
Intercept	Pillai's Trace	.993	4276.701^b	3.000	84.00	.000	.993
	Wilks' Lambda	.007	4276.701^b	3.000	84.00	.000	.993
	Hotelling's Trace	152.739	4276.701^b	3.000	84.00	.000	.993
	Roy's Largest Root	152.739	4276.701^b	3.000	84.00	.000	.993
Groups	Pillai's Trace	.871	188.776^b	3.000	84.00	.000	.871
	Wilks' Lambda	.129	188.776^b	3.000	84.00	.000	.871
	Hotelling's Trace	6.742	188.776^b	3.000	84.00	.000	.871
	Roy's Largest Root	6.742	188.776^b	3.000	84.00	.000	.871
Gender	Pillai's Trace	.102	3.197^b	3.000	84.00	.028	.102
	Wilks' Lambda	.898	3.197^b	3.000	84.00	.028	.102
	Hotelling's Trace	.114	3.197^b	3.000	84.00	.028	.102
	Roy's Largest Root	.114	3.197^b	3.000	84.00	.028	.102
Groups * Gender	Pillai's Trace	.107	3.357^b	3.000	84.00	.023	.107
	Wilks' Lambda	.893	3.357^b	3.000	84.00	.023	.107
	Hotelling's Trace	.120	3.357^b	3.000	84.00	.023	.107
	Roy's Largest Root	.120	3.357^b	3.000	84.00	.020	.107

The results presented in Table 11 indicate a statistically significant difference between the two groups of students in terms of their scores on ASI [$F(1, 49.900) = 49.900$, $p = .000$, partial η2 = .748], ESL [$F(1, 49.767) = 49.767$, $p = .000$, partial η2 = .785], and CIS [$F(1, 43.992) = 43.992$, $p = .000$, partial η2 = .797]. The post-Hoc comparison test and significant differences appear in Tables 12 and 13. On the other hand, Table 11 indicates gender-based differences in student scores on ESL [$F(1, 1.022) =1.022$, $p = .013$, partial η2 = .070] and CIS [$F(1,.845) = 0.845$, $p = .013$, partial η2 = .070]. Nevertheless, the two groups had no significant difference in the ASI scores [F (1,.243) =.243, p = .268, partial η2 = .014)]. Tables 14 and 15 show significant differences and a post hoc Bonferroni comparison test.

Table 11
Two-way MANOVA for Group- and Gender-based TOSRA Scales

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared (η2)
Intercept	ASI	944.820	1	944.820	4844.800	.000	.983
	ESL	1085.935	1	1085.935	6849.066	.000	.988
	CIS	1131.294	1	1131.294	8684.550	.000	.990
Groups	ASI	49.900	1	49.900	255.875	.000	.748
	ESL	49.767	1	49.767	313.883	.000	.785
	CIS	43.992	1	43.992	337.713	.000	.797
Gender	ASI	0.243	1	.243	1.244	.268	.014
	ESL	1.022	1	1.022	6.449	.013	.070
	CIS	.845	1	.845	6.487	.013	.070
Group * Gender	ASI	1.428	1	1.428	7.323	.008	.078
	ESL	.815	1	.815	5.140	.026	.056
	CIS	.030	1	.030	.234	.630	.003
Error	ASI	16.772	86	.195			
	ESL	13.635	86	.159			
	CIS	11.203	86	.130			
Total	ASI	1024.110	90				
	ESL	1159.330	90				
	CIS	1195.370	90				
Corrected Total	ASI	70.883	89				
	ESL	67.305	89				
	CIS	56.881	89				

The ANOVA results for ASI, ESL, and CIS among students exposed to different instructional methods are presented in Table 12. The analysis revealed statistically significant differences in these variables [F (1, 52.441) = 250.231, p = .000 < .05; F (1, 51.832) = 294.788, p = .000 < .05; F (1, 44.803) = 326.426, p = .000 < .05, respectively].

Table 12
TOSRA-Scales Measured by Groups ANOVA Results

		Sum of Squares	df	Mean Square	F	Sig.
ASI	Between Groups	52.441	1	52.441	250.231	.000
	Within Groups	18.442	88	.210		
	Total	70.883	89			
ESL	Between Groups	51.832	1	51.832	294.788	.000
	Within Groups	15.473	88	.176		
	Total	67.305	89			
CIS	Between Groups	44.803	1	44.803	326.426	.000
	Within Groups	12.078	88	.137		
	Total	56.881	89			

The post-hoc analysis was carried out using the Bonferroni correction for multiple comparisons (see Table 13). A review of the mean scores revealed that students in the EGs performed much better than students in the CGs. At p =.05, students in the EGs reported significantly higher ratings for ASI, CIS, and ESL than those in the CGs. In addition, a mean score analysis revealed that CIS had the greatest mean score, ESL was the second highest, and ASI displayed the lowest mean score.

Table 13
Analyses of Post-hoc Test by Student Groups and TOSRA Scales

						95% Confidence Interval for difference	
Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.b	Lower Bound	Upper Bound
ESL	CGs	EGs	-1.497*	0.084	.000	-1.664	-1.329
	EGs	CGs	1.497*	0.084	.000	1.329	1.664
CIS	CGs	EGs	-1.407*	0.077	.000	-1.559	-1.255
	EGs	CGs	1.407*	0.077	.000	1.255	1.559
ASI	CGs	EGs	-1.499*	0.094	.000	-1.685	-1.312
	EGs	CGs	1.499*	0.094	.000	1.312	1.685

ANOVA results in Table 14 demonstrate no statistically significant differences in ASI [F (1, .243) = 1.244, p = .268 >.05]. ESL, on the other hand, showed a statistically significant difference [F (1, 1.022) = 6.449, p = .013 < .05]. There were also significant differences in CIS scores [F (1, .845) = 6.487, p = .013 < .05] amongst students who received various instructional methods.

Table 14
Gender-Specific TOSRA-scale ANOVA Results

		Sum of Squares	df	Mean Square	F	Sig.
ESL	Between Groups	1.022	1	1.022	6.449	.013
	Within Groups	66.283	88	.753		
	Total	67.305	89			
CIS	Between Groups	.845	1	.845	6.487	.013
	Within Groups	56.036	88	.637		
	Total	56.881	89			
ASI	Between Groups	.243	1	.243	1.244	.268
	Within Groups	70.641	88	.803		
	Total	70.883	89			

The post-hoc analysis was carried out using Sidak for multiple comparisons (see Table 15). An examination of the mean scores indicated that male students exhibited a greater degree of attitudes concerning ASI than female students at a significance level of p = .05; however, the difference was not statistically significant. Attitudes toward CIS were substantially greater among female students than male students, with a p-value of .05. In terms of Attitudes toward ESL, female students demonstrated a considerably higher level than male students at p = .05. Additionally, a mean score study revealed that CIS exhibited the greatest mean score, followed by ESL. At the same time, the ASI displayed the lowest mean score.

Table 15
Post Hoc Tests for Student Gender and TOSRA Attitudes

						95% Confidence Interval for Difference[b]	
Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
ASI	Male	Female	-.105	.094	.268	-.291	.082
	Female	Male	.105	.094	.268	-.082	.291
ESL	Male	Female	-.214*	.084	.013	-.382	-.047
	Female	Male	.214*	.084	.013	.047	.382
CIS	Male	Female	-.195*	.077	.013	-.347	-.043
	Female	Male	.195*	.077	.013	.043	.347

Finally, Table 16 presents the results of a statistical analysis that examines the multivariate interaction effect of *Groups* × *Gender* on scores of ASI and ESL. The analysis reveals statistically significant differences in these scores [F (1, 1.428) = 1.428, p = .008, partial η2 = .078 for ASI; F (1, .815) = .815, p = .026, partial η2 = .056 for ESL]. However, concerning interactions between groups and genders, no statistically significant differences were noticed in their scores on the CIS measure [F (1, .030) = .030, p = .630, partial η2 = .003]. This suggests that male and female students' attitudes improved more in CSs-based ASI and ESL instruction. However, CSs-based learning environments did not change students' CIS attitudes in either gender.

Table 16
TOSRA Scale Means and Standard Deviations by Gender

			EGs		CGs	
	Gender	N	Mean	Std Deviation	Mean	Std Deviation
ASI	Male	25	4.08	.27	2.33	.59
	Female	20	3.93	.42	2.69	.40
	Total	45	4.01	.34	2.49	.54
ESL	Male	25	4.23	.30	2.54	.44
	Female	20	4.25	.38	2.95	.44
	Total	45	4.24	.33	2.72	.48
CIS	Male	25	4.19	.32	2.74	.42
	Female	20	4.35	.23	2.98	.41
	Total	45	4.26	.29	2.8511	.43

7. Discussion

The current study found significant differences between EGs and CGs in ASI, ESL, and CIS. It is worth noting that the EGs exhibit a positive attitude toward ASI, ESL, and CIS because of the students' interactions. In this instance, CSs positively affect students' attitudes toward physics learning. Likewise, the incorporation of CSs significantly influences the attitudes of both male and female students toward physics. This is because CSs can offer simplified representations of various phenomena, promoting student engagement in activities such as observation, discovery, reconstruction, and receiving prompt feedback on objects, events, and processes. Using CSs, students can manipulate variables and monitor the outcomes to generate scientific findings. CSs have the potential to offer functionalities that allow for the visualization of activities that are hazardous, time-consuming, or intricate, hence facilitating interactions within classroom or laboratory settings (McDonald, 2016;

Widiyatmoko, 2018; Blake & Scanlon, 2007; Couch, 2014). According to the literature, improved physics performance has been linked to more positive attitudes (Kattayat et al., 2016; Sari et al., 2019). In this study, CSs improved students' attitudes, which may inspire them to study physics more. Kattayat et al. (2016), Sari et al. (2019), Sarı et al. (2017), and Oymak and Ogan-Bekiroglu (2017) discovered that including CSs in instruction improves student learning and attitudes toward physics. The findings of Kattayat et al. (2016) were also supported by this study, which demonstrated a favorable and significant association between the achievement of adolescent students exposed to CSs-assisted instruction and their attitude toward Physics.

The study found a significant difference in science lesson enjoyment scores between EGs and CGs. Lessons enjoyment increased significantly for EGs. Similar to this study, Quinn and Lyons (2011) and Osborne and Collins (2001) discovered that Australian students enjoy science, which may influence their attitudes toward science. Gorard and See (2011) stated that student involvement and learning may improve with more learning enjoyment. Because CSs' delivery and activities are engaging and varied, students enjoy physics classes (Gorard & See, 2011).

The findings indicate that female participants had considerably more positive perceptions of the impact of CSs on their learning of physics. Additionally, they expressed higher levels of enjoyment in their physics lessons. According to the findings of Stewart (1998), the factor of enjoyment holds greater importance for females compared to boys when it comes to their selection of physics as a subject. In contrast to 21% of male students, 40% of female students who pursued Physics at the A-Level indicated that Physics was their preferred subject during their General Certificate of Secondary Education (GCSE) studies. In a study conducted by Elwood and Carlisle (2003), a sample of 247 students from years 12 and 13 in England were questioned to assess their attitudes regarding different components of the A-level physics course. The study indicated that most students were confident and enjoyed the topic, with female students enjoying it more than male students. In contrast to this finding, the prior research indicated that male students enjoyed physics lessons more than female students (Kost et al., 2009). According to Reid's (2003) findings, there is a notable difference between the enjoyment levels of girls and boys in physics lessons. Girls are less likely to enjoy physics lessons than boys, tend to experience higher levels of boredom, and have challenges engaging in discussions or conducting experimental activities within this context. Female students were more pessimistic about physics and chemistry than boys, according to Seba et al. (2013). Negative attitudes in female students are linked to anxiety, low self-esteem, and poor physics and chemistry enjoyment. In conclusion, students' attitudes about physics classes are most directly related to their intentions to participate in debates, experiments, and awareness of their academic progress.

The study revealed a statistically significant difference in the attitude scores regarding career interest in physics/science between the two student groups. The study showed that most students were inclined to pursue careers in physics or science due to their engagement with CSs within the learning environment. This favorable attitude may stem from the students' utilization of CSs in designing and their recognition of the practical applicability of their acquired knowledge. It thus enhances students' social awareness and independence (Hidayati et al., 2017; Tairab & Wilkinson, 1991). According to Putra et al. (2019), students may choose to preserve their flexibility and pursue a career in physics if they spend time studying physics and are satisfied doing so. The number of women in science in the US has rapidly expanded over the past five years; for instance, the percentage of women in the biological sciences rose from 28% to 49% among scientists working in the United States between 1960 and 2013. In contrast, the percentage in chemistry increased from 8% to 35%. The physics and astronomy ratio rose from 3% to 11% (Miller & Wai, 2015). Such an increase can be linked to the student enjoyment of science- an indicator of positive attitudes toward and interest in science.

Additionally, the study findings indicate that males exhibit lower levels of interest in pursuing a profession in physics or science when compared to girls. Males tend to experience boredom and decreased attentiveness during physics classes, leading to a perception of physics as less attractive. While the students believe that physics is connected to their prospective careers, male students do not express an intention to pursue higher education (Elwood & Carlisle, 2003). Students also mentioned that a career in physics or science is uninteresting because most of their time will be spent in the laboratory and that they need a deeper understanding of the career of physics or science to succeed (Sukarni et al., 2020).

This study contradicted Seba et al. (2013), who found that boys' and girls' different attitudes toward science lead to the lowest number of women in science. In their meta-analysis, Miller et al. (2018) observed that students often associate scientists with men. Reid (2003) found that twice as many males had a good attitude toward physics as females in Scottish schools, and students reported interest in studying physics after 16 because of its relevance to their careers and other life. The experience of failing to learn physics in school is usually the cause of a lack of interest in pursuing a profession in science or physics (Astalini et al., 2019).

In the UAE context, the reduction in boys studying science and physics may be due to a lack of scientifically trained men in the UAE to mentor young boys. Scientifically skilled workers benefit the economy and are needed (Hill et al., 2010). Therefore, Future teachers may require more training, especially in physics, to teach the next generation.

8. Implication and Recommendations

Several implications can be drawn from the findings of this study. One of the key implications is that CSs have the potential to significantly enhance the attitudes of secondary school students toward physics. Furthermore, CSs can assist students in visualizing and comprehending intricate physics principles. Also, CSs can tailor learning experiences, cater to the specific needs of each student, and foster a more captivating and exciting educational setting.

Therefore, this study proposes these recommendations: 1) Teachers should incorporate CSs into physics curricula. CSs can help students envision abstract concepts, do virtual experiments, and solve problems to improve their knowledge. 2) CSs can be tailored to different learning styles and levels. This makes learning more inclusive. 3) Train and develop teachers to use simulations effectively. Teachers should lead simulations to promote critical thinking and conversation. 4) Promote long-term study on computer simulations' effects on students' attitudes toward physics. This may involve longitudinal research to see if good attitudes lead to maintained engagement and better academic performance.

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