Enhancing STEM learning outcomes at a few secondary schools in Ijebu Ode LGA of Ogun State through inquiry learning spaces (ILS)

[d,a]Ekine Adefunke, O., [d,b]Tobih Deborah, O., [d,c]Lawani Abisola [d,e]Adewale Kayode

[a]Department of Childhood Education, College of Specialized and Professional Education,

[b,e]Department of Counselling Psychology and Educational Foundations, College of Specialized and Professional Education,

[c]Department of Mathematics, College of Science, and Information Technology

[d]Tai Solarin University of Education, Ogun State, Nigeria

E-mail: ekineao@tasued.edu.ng; tobihdo@tasued.edu.ng; adewalepg@tasued.edu.ng

Abstract

Technology prepares young people to become better at research and critical thinking that may enhance problem-solving skills, encourage teamwork, collaboration, and application of knowledge to new situation. Inquiry Learning Space (ILS) is therefore a technological innovation needed to foster learning particularly in STEM education. This study employed quasi-experimental research design of pre- and post-tests. Purposive sampling was employed to select participants (teachers) from the 2016 prior TETFund Project STEM teachers from both private and public schools who had been trained on gender sensitivity. Sixty-five (65) STEM teachers from Public and private schools in Ijebu Ode LGA were used for the study. In addition, teachers were asked to administer test and record the scores of students' participants (257 students) before and after using ILS for teaching. Two questionnaires (teacher and student version) with r = .93; r = .86 respectively was developed by the researchers and administer before and after the training to the teachers. Six hypotheses were tested. Data were analysed using descriptive statistics, percentages, t-test, and Multiple Regression Analysis. The results showed a significant difference in mean attitude of public and private school teachers respectively towards the use of ILS ($t_{(95)} = 6.41$, $p = .000$) ; ($t_{(29)} = 4.17$, $p = .000$). Furthermore, it showed that there was a significant difference in students' score before and after the use of ILS ($t_{(512)} = 15.10$, $p = .000$). It is therefore recommended that all STEM teachers be trained and encouraged to employ the use of ILS in the teaching of STEM subjects

Keyword: *Inquiry Learning Space, Virtual Laboratories, Go-Ga Master, STEM*

Introduction

The poor use of science, technology, and innovation (STI) for economic growth is one of the reasons why many Sub-Saharan African (SSA) nations have poor economic performance. According to Croak (2018), STEM education has a beneficial impact on productivity across all subject areas. In the modern knowledge society, the countries achieving the necessary developmental progress are those that have adopted STI through dedicated and focused investment in STI. Science, Technology, Engineering, and Mathematics (STEM) are the primary forces behind innovation, which is essential for economic progress. They also act as instruments for raising standards of life, enhancing competitiveness, and generating knowledge for problem-solving through research and development. The activities of the 21st century are influenced by science and technology, as well as a nation's capacity to ensure health, combat disease, and safeguard the environment.

According to Croak (2018), STEM education is related to both the character of the work force and technology/innovation. Marginson, Simon, Tytler, Freeman and Roberts (2013) stated that educational quality as determined by cognitive abilities, mainly in science and mathematics is a

more accurate indicator of economic results than general educational indices. Marginson et al.(2013) compared STEM education across different nations and found that the quantity and quality of STEM competences affects economic performance – though in most nations there is less programmatic focus on the links between education in STEM, and the take-up of STEM skills in the labour markets. In addition, there is a lot of interest in developing advanced STEM brains that are connected to both business innovation and research and development. This is due to the widespread belief that the amount and caliber of STEM competencies have an impact on economic success. As a result, increasing the general standard of the human capital supply and expanding the high skill group that is capable of study, invention, and effective reaction to technological change should be a major emphasis.

In the study of the value of STEM education for productivity, Atkinson and Mayo (2010) found that the main motivation for STEM education is to supply the "fuel" needed to power a technology-driven economy since technological innovation has been credited with up to 75% of the growth in the American economy since World War II. Again, without a population that is trained in science, technology, engineering, and mathematics, such science and technology-based innovation is impossible. Therefore, the innovation economy and its possibilities will fail without the appropriate quantity and quality of people with STEM education. Hence, STEM education is a valuable platform for preparing the nation's kids for the challenges that lie ahead in a highly competitive technological World. It should be emphasized as well that the ability to acquire, learn from, adapt to, use, and create from existing technology is becoming a more important metric h to measure international competitiveness. In other words, countries that do not innovate become less competitive. So, the provision of STEM education for its citizens at the primary level of school determines the main distinction between the developed and developing worlds.

STEM skills, including those in information and communication technology (ICT), are becoming more and more important across disciplines as technology advances at a rapid rate. Information and communication technology (ICT) skills, particularly, are becoming more applicable across disciplines as technology advances at a rapid rate. In order to create a pool of scientists, engineers, technologists, and innovators who are well-trained and equipped with the necessary skills to drive the various sectors of the economy and maintain Nigeria's leadership in research, innovation, and technological development, we must therefore strengthen the acquisition of STEM skills at all levels. The way people perceive, interact, and learn has changed because of technology. It gradually has significant effects on Nigeria's educational system, affecting everything from how students learn to how teachers develop their own expertise and improve learning environments, as well as how administrators oversee grades, uphold security, monitor payments, and follow up with guardians or parents. The use of technology enables educators to have an impact outside of the classroom. Today's instructors can instruct pupils, follow up with them, and give advice from anywhere in the world by using video conferencing and chat platforms. Teaching and learning are improved by technology in both their purpose and enjoyment. It could greatly simplify and make learning for kids more interesting. The possibilities for using technology in education are virtually endless (Oyin, 2021)

In the Nigerian school system, software like Inquiry Learning Space (ILS) and Go-Ga Lab can be used for e-learning to supplement instructors' lessons and increase students' learning ability. Technology can be used by the teacher to keep tabs on pupil assignments and classroom development. By establishing connections to the actual world, inquiry-based learning engages

students via research and difficult questions. It is a teaching strategy that encourages students to experiment and solve problems. According to Jong, Rodríguez-Triana, Hovardas, Dikke, Dziabenko, Koslowsky, Korventausta, Law, Pedaste, Tasiopoulou, Vidal, and Zacharia (2021), inquiry learning can help students develop their critical thinking abilities because it is created to bring students straight into the scientific method in a brief amount of time.

As good as this software (ILS) is, the attitude of teachers towards the use of it is the driver for its implementation in the classrooms. Sanchez et. al. (2012) reported in their findings that teachers' attitudes towards ICT are highly positive but the use of them in class is scarce and it is subjected to innovative processes.

Ertikanto, Herpratiwi, Yunarti and Saputra (2017) and Jeon., Kellogg, Khan, and Tucker-Kellogg (2021) demonstrated how inquiry activities can enhance students' knowledge of science, stimulate their ability to think creatively, and develop their skills in gathering and analyzing data. ILS are online and digital learning spaces where students can engage with virtual laboratories and other multimedia tools like text and pictures as well as other learning materials (Jong et al, 2021). ILS can offer pupils a context-based environment and instructional assistance for learning, to put it briefly. With today's cutting-edge technology, inquiry-based learning can use digital tools like interactive visualization and virtual labs to help students comprehend difficult science concepts and solve issues. If Nigeria is to achieve its goal of becoming one of the world's top innovators by 2030 and reach the SDG goals, its educational system must be improved, and money must go into teacher training programme that emphasize using cutting-edge techniques. Many online learning platforms provide students with access to a variety of virtual labs, such as Go Lab, which streamline learning by emphasizing key factors, eliminating irrelevant details, and changing time scales to make exploring and analyzing scientific phenomena simpler (Gnesdilow and Puntambekar, 2021)

Using the Go-lab platform and ILS, Jung., Hsin-Cheb., Cheng and Chun-Yen (2022) looked into student technology adoption, the knowledge integration (KI) process, and learning results for both high- and low-achieving KI students. The research revealed that KI students reacted favourably to the platform's perceived utility. Although, the low achievers KI students almost created simple links, (ii) the high achievers KI students could progressively develop connections from simple to complex and varied among genetic concepts, and (iii) the higher achiever and low achiever KI students had comparable academic achievement. The cooperative initiative GO-GA has been funded by the European Commission through the Horizon 2020 Research and Innovation Financing Program (Go-Lab Goes Africa). The objective of GO-main GA is to hasten the uptake of richer learning settings and enhance learning results in science and technology through the application of contextually engaging digital STEM education in secondary schools across Africa. With the goal of expanding, it across all of Africa, GO-GA will adjust the Go-Lab Ecosystem, which comprises the websites www.golabz.eu and www.graasp.eu, to the requirements of teachers and pupils in Nigeria, Kenya, and the Republic of Benin.

Go-Lab is a well-known platform that provides secondary schools with carefully selected, tried-and-true scientific and technological material, supported by a strong teaching community. Tai-Solarin University of Education has been chosen as a hub for the teacher training component of the Go Lab initiative, with three employees acting as Master Trainers. To evaluate the use of

inquiry-based learning (ILS) in the instruction of some selected STEM subjects, this initiative is an intervention programme for SS1 class students in both private and public schools.

Statement of the Problem

A high-quality education is not conceivable without a high-quality teacher (Global Education Report, 2012), and neither can any education surpass the quality of the teacher, (Federal Republic of Nigeria (FRN), 2012) In literature, several creative approaches and strategies have been identified to support the teaching and learning of science, including the inquiry learning approach which encourages critical thinking by allowing students to reflect, collaborate, and ask questions. All of these are necessary abilities for the workforce of today, and STEM classes may foster them with the right teaching strategies. For certain chosen STEM instructors from 55 schools across four local governments area in Ogun, this intervention initiative would therefore function as a scaling up.

Purpose of the Study

Analyze the impact of inquiry learning spaces (ILS) on STEM student learning in some selected schools. Specifically, it is aimed to

1. determine the difference in the attitude of teachers of both public and private schools before and after training towards the use of ILS.
2. determine the influence of demographic data (Gender, age, Qualification, Specialization, working experience, Subject taught and Type of school) on teachers' attitude on the use of ILS
3. determine influence of demographic data (Local govt area, Class, Gender, Type of school) on students' attitude before and after training towards the use of ILS.
4. Find the difference in the mean score of students before and after training in the use of ILS.

Research Hypotheses

H_{01}. There is no significant difference in the attitude of teachers of public secondary schools before and after training towards the use of ILS.

H_{02}. There is no significant difference in the attitude of teachers of private secondary schools before and after training towards the use of ILS.

H_{03}: There is no significant difference in the attitude of teachers of public and private secondary schools before and after training towards the use of ILS.

H_{04}. There is no significant influence of demographic data (Gender, age, Qualification, Specialization, working experience, Subject taught and Type of school) on secondary school teachers' attitude on the use of ILS

H_{05}. There is no significant influence of demographic data (Local govt area, Class, Gender, Type of school) on the attitude of secondary school students before and after training towards the use of ILS.

H_{06}: There is no significant difference in the mean score of secondary school students before and after being taught through the use of ILS.

Methodology

The study employed a quasi-experimental design of pre- and post-tests. After permission had been sought from the Ministry of Education in Ogun State, purposive sampling was employed by selecting participants (secondary school teachers) who had been trained on gender sensitivity from the 2016 prior TETFUND Project. Sixty-five STEM teachers from both private and public

schools selected from nine schools in Ijebu Ode LGA were trained in the use of ILS after which they adopted the skills in the respective classes of their schools. Teachers were asked to administer test and record the scores of students' participants (257 students) before and after using ILS for teaching. The chief researcher and one of the trained co-researchers, along with the Go-Ga Master trainers, oversaw the training and monitored the class practical. Two questionnaires (teacher and student version) consisting of 42 items each assessing biographic data and attitude of teachers and students to the use of ILS (r = .93; r = .86 respectively) was developed by the researchers and administer before and after the training to the teachers. Six hypotheses were tested. Data were analyzed using descriptive statistics, t-test, and multiple regression analysis.

Results

Research Hypotheses

$H_0$1. There is no significant difference in the attitude of teachers of public secondary schools before and after training towards the use of ILS.

To test this hypothesis, t-test statistics was used, and the result is presented in table 1.

Table 1: T-test Results comparing Public school Teachers' attitude before and after training in the use of ILS

	Prepost	N	Mean	SD	SE	t	df	P	Decision
Teachers Attitude	pretraining	50	25.74	12.97	1.83	6.41	95	.000	reject
	posttraining	47	38.21	4.46	.65				

Table 1shows the mean attitude of public school teachers before and after training respectively as shown: ((M = 25.74, SD = 12.97; M = 38.21, SD = 4.46). Since Levene's $p < .05$, equality of variance is not assumed. The mean difference between pre and post training was 12.47 and the 95% confidence interval for the estimated population mean difference is between -16.43 and -8.51. the effect size was large (d = 2.91). Result then shows a significant difference in the attitude of public school teachers towards the use of ILS ($t_{(95)} = 6.41$, $p = .000$). this implies that the training in the use of ILS improved teachers' attitude towards the use of ILS as a teaching method in the public schools.

H_{02}. There is no significant difference in the attitude of teachers of private secondary schools before and after training towards the use of ILS.

To test this hypothesis, t-test statistics was used, and the result is presented in table 2.

Table 2: T-test Results comparing Private school Teachers' attitude before and after training in the use of ILS

	Prepost	N	Mean	SD	SE	t	df	P	Decision
Teachers Attitude	pretraining	15	29.60	7.41	1.91	4.17	29	.000	reject
	posttraining	16	39.06	4.89	1.22				

Table 2 shows the mean attitude of teachers from the private schools before and after training respectively as shown: (M = 29.60, SD = 7.40; M = 39.06, SD = 4.89). Since Levene's $p < .05$, equality of variance is not assumed. The mean difference between pre and post training was 9.46 and the 95% confidence interval for the estimated population mean difference is between -14.04 and -4.88. the effect size was large (d = 1.54). Result then show a significant difference in mean attitude of private school teachers towards the use of ILS ($t_{(29)} = 4.17$, $p = .000$). this implies that the training in the use of ILS improved teachers' attitude towards the use of ILS as a teaching method in private schools.

Comparing public and private school teachers together gives the following hypothesis was postulated

H_{03}. There is no significant difference in the attitude of teachers of public and private secondary schools before and after training towards the use of ILS.

To test this hypothesis, t-test statistics was used, and the result is presented in table 3.

Table 3: T-test Results comparing Public and Private school Teachers' attitude before and after training in the use of ILS

	Prepost		N	Mean	SD	SE	t	df	P	Decision
Teachers Attitude	pretraining	Public	50	25.74	12.97	1.83	1.09	63	.28	accept
		Private	15	29.60	7.40	1.91				
Teachers Attitude	posttraining	Public	47	38.21	4.46	.65	.64	61	.52	accept
		Private	16	39.06	4.89	1.22				

Table 3 shows the mean attitude of public and private school teachers before and after training respectively as shown: ((M = 25.74, SD = 12.97; M = 29.60, SD = 7.40; M = 38.21, SD = 4.46; M = 39.06, SD = 4.89). In addition, results shows no significant difference in the attitude of public and private school teachers based on the training in the use of ILS ($t_{(63)} = 1.09$, $p = .28$; $t_{(61)} = .64$, $p = .52$). The null hypothesis is failed to be rejected.

H_{04}. There is no significant influence of demographic data (Gender, age, Qualification, Specialization, working experience, Subject taught and Type of school) on secondary school teachers' attitude on the use of ILS

Again, the influence of demographic data on teachers' attitude was tested using Multiple regression and the result is presented in table 4

Table 4a: Model Summary for teachers

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.443[a]	.196	.135	10.08037

a. Predictors: (Constant), Gender, age, Qualification, Specialization, working experience, Subject taught, Designation, Type of school

Table 4b: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2923.054	9	324.784	3.196	.002[b]
	Residual	11990.446	118	101.614		
	Total	14913.500	127			

a. Dependent Variable: Teachers' attitude

b. Predictors: (Constant), Gender, age, Qualification, Specialization, working experience, Subject taught, Designation, Type of school

Table 4b shows that there was a significant influence of all demographic data of teachers on their attitude towards the use of ILS as a teaching strategy. However, results show that demographic data (Gender, age, Qualification, Specialization, working experience, Subject taught, Type of school) contributed 13.5% to the attitude of teachers in the use of ILS. Using the enter method, a significant model emerged: $F(9, 118) = 3.196$, $p < .005$

Table 4c: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.552	11.162		.497	.620
	Gender	.561	2.127	.023	.264	.792
	age	-.336	1.563	-.027	-.215	.830
	Qualification	4.270	2.450	.154	1.742	.084
	Specialization	1.755	.554	.284	3.167	.002
	Subjtaught	.180	.594	.029	.302	.763
	Designation	-1.560	1.742	-.085	-.896	.372
	Working experience	.860	.850	.110	1.011	.314
	Type of school	5.021	2.659	.199	1.889	.061
	Local govt area	4.382	1.295	.324	3.383	.001

a. Dependent Variable: Teachers' attitude

All the predictor variables except specialization and local government area of the schools were not significant predictors of teachers' attitude

H_{05}: There is no significant influence of demographic data (Local govt area, Class, Gender, Type of school) on the attitude of secondary school students before and after training towards the use of ILS.

Table 5a: Model Summary for students

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.745[a]	.555	.553	4.482

c. Predictors: (Constant), Local govt area, Class, Gender, Type of school, age

Table 5b: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34688.077	6	5781.346	287.849	.000[b]
	Residual	27777.066	1383	20.085		
	Total	62465.143	1389			

a. Dependent Variable: students' attitude

d. Predictors: (Constant), Local govt area, Class, Gender, Type of school, age

Table 5 shows that there was a significant influence of all demographic data of students on their attitude towards the use of ILS as a teaching strategy. However, results show that demographic data (Gender, age, Classs, Type of school and local government area) contributed 55.3% to the attitude of students in the use of ILS. Using the enter method, a significant model emerged: F (6, 1383) = 287.85, p < .005.

Table 5c: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.189	1.517		4.740	.000
	Gender	-.274	.241	-.020	-1.138	.256
	age	.058	.085	.016	.683	.495
	Class	-.236	.142	-.037	-1.664	.096
	Type of school	-1.006	.356	-.056	-2.822	.005
	Local govt area	-1.351	.601	-.041	-2.246	.025

a. Dependent Variable: students' attitude

All the predictor variables in Table 5c except type of schools and local government area of the school were not significant predictors of students' attitude at p<.05

H_{06}: There is no significant difference in the mean score of secondary school students before and after being taught through the use of ILS.

Students were given a test before and after the use of ILS, results is presented in table 6

Table 6: T-test Results comparing the mean score of secondary school students before and after training in the use of ILS.

	Prepost	N	Mean	SD	SE	t	df	p	Decision
score	pretraining	257	12.64	2.65	.17	15.09	512	.000	Reject
	posttraining	257	15.63	1.76	.11				

Table 6 shows the mean score of students before and after being taught through the use of ILS respectively as shown: (M = 12.64, SD = 2.65; M = 15.63, SD = 1.76). Since Levene's $p < .05$, equality of variance is not assumed. The mean difference between pre and post training score was 2.99 and the 95% confidence interval for the estimated population mean difference is between -3.38 and -2.60. the effect size was large (d = 0.68). Result then show a significant difference in students' score before and after the use of ILS ($t_{(512)} = 15.10$, $p = .000$). This implies that the use of ILS improves students' academic achievement.

Discussion

The entry attitudes of teachers were observed, comparing public school teachers' attitude with that of private school teachers' attitude before and after the training in the use of ILS. The result showed no significant difference in the entry attitude of public and private teachers towards the use of ILS. This shows that both categories of teachers were at the same level in their attitude when the training was about to start and also after the training, there was no significant difference in the attitude of public and private school teachers based on the training in the use of ILS (Table 3). It then implies that the training in the use of ILS had the same impact on the attitude of both private and public secondary school teachers. Furthermore, comparing the teachers' attitude before and after training for private and public schools separately, results showed a significant difference for both categories of teachers (Table 1&2) indicating that teachers attitude towards the use of ILS was improved after the training. The study's finding is consistent with previous studies that show the positive impact of training on teachers' attitudes towards ILS (Ajayi & Ojo, 2019; Song et al., 2020). The result also confirms that teachers play a crucial role in the success of ILS as a teaching strategy (Liu et al., 2018).

The study revealed that demographic data (gender, age, qualification, specialization, working experience, subject taught, and type of school) significantly influenced teachers' attitudes towards the use of ILS as a teaching strategy (Tables 4a,b & c). However, demographic data contributed only 13.5% to teachers' attitude toward the use of ILS. The finding is consistent with previous studies that show that demographic data have a limited influence on teachers' attitudes towards ILS (Lee & Lee, 2015; Liu et al., 2018). Similarly for students, findings showed 55.3% contribution of demographic data (Gender, age, Class, Type of school, Local govt area) to their attitude.

In addition, the study showed a significant difference in the mean score of students before and after training in the use of ILS (Table 6). The result implies that the use of ILS as a teaching strategy improved students' academic performance. The finding is consistent with previous studies that show the positive impact of ILS on students' academic performance (Chen et al., 2015; Lee & Lee, 2015) and the studies on the effectiveness of training in improving the attitude of teachers towards the use of ICT (Aduwa-Ogiegbaen & Iyamu, 2018; Akudolu, 2021).

The study also found that demographic factors significantly influenced the attitude of teachers and students toward the use of ILS. (Tables 4 & 5) The result suggests that teachers' and students' background characteristics are essential in understanding their attitudes toward the use of technology in education.

However, the study found that there was no significant difference in the mean score of students before and after training in the use of ILS is contrary to previous studies (Barton & Haydn, 2015;

Kirschner et al., 2018) that have shown the effectiveness of ILS in improving students' academic performance. One possible explanation for this finding could be that the student's previous knowledge and experience with ICT influenced their attitude toward the use of ILS, and this was not captured in the study. Therefore, future studies should investigate the relationship between students' prior experience with ICT and their attitude toward the use of ILS.

The study's finding is consistent with previous studies that show the positive impact of training on teachers' attitudes towards ILS (Ajayi & Ojo, 2019; Song et al., 2020). Liu et al. (2018) also highlighted that teachers play a crucial role in the success of ILS as a teaching strategy. Aduwa-Ogiegbaen & Iyamu (2018) and Akudolu (2021) found that training was effective in improving teachers' attitudes towards the use of ICT. The finding that demographic data have a limited influence on teachers' attitudes towards ILS is also supported by Lee & Lee (2015) and Liu et al. (2018).

The study also found that the use of ILS as a teaching strategy improves students' academic performance, consistent with previous studies (Chen et al., 2015; Lee & Lee, 2015). However, the study's finding that there was no significant difference in the mean score of students before and after training in the use of ILS is contrary to previous studies (Barton & Haydn, 2015; Kirschner et al., 2018). One possible explanation for this finding could be that the student's previous knowledge and experience with ICT influenced their attitude toward the use of ILS, and this was not captured in the study.

The study's findings have implications for both teachers and students. Teachers need to be trained in the use of ILS to improve their attitude toward its use as a teaching strategy. The finding that demographic data significantly influence teachers' attitude towards ILS also suggests that teachers' background characteristics should be considered when implementing ILS. For students, the finding that ILS improves their academic performance highlights the importance of technology in education. Future studies should investigate the relationship between students' prior experience with ICT and their attitude toward the use of ILS to better understand the impact of technology on education.

Conclusion

The study investigated the difference in the attitude of teachers in public and private schools towards ILS before and after training, the influence of demographic data on teachers' attitudes towards ILS, and the difference in the mean score of students before and after training in the use of ILS. The study found that training in the use of ILS improves teachers' attitudes towards the use of ILS as a teaching method in both public and private schools. Demographic data significantly influences teachers' attitudes towards the use of ILS, but it contributes only a small percentage. The study also found that the use of ILS as a teaching strategy improves students' academic performance. The finding is consistent with previous studies that show the positive impact.

References

Adomi, E., & Omodeko, F. (2016). Effect of training on teachers' attitude towards the use of instructional technology in teaching in Nigeria. International *Journal of Education and Development using Information and Communication Technology*, 12(2), 77-88.

Aduwa-Ogiegbaen, S. E., & Iyamu, E. O. S. (2018). Use of information and communication technology (ICT) in teaching and learning: An analysis of WebCT use in Nigerian universities. Educational Media International, 55(3), 219-234.

Ajayi, L. B., & Ojo, E. B. (2019). Impact of training on teachers' attitudes towards instructional materials and improvisation. International Journal of Instruction, 12(4), 1107-1120.

Akinbobola, A. O.(2017). Teachers' attitudes towards the use of interactive whiteboards in teaching and learning in Oyo state, Nigeria. *Journal of Education and Practice*, *8*(3), 78-83.

Akudolu, I. O. (2021). The impact of information and communication technology (ICT) training on teachers' job performance in Delta State, Nigeria. International Journal of Scientific Research and Management, 9(2), 10492-10501.

Atkinson, Robert D. & Merrilea Mayo (2010). Re-fueling the US innovation economy: Fresh approaches to STEM education. *The Information Technology & Innovation Foundation.* 1-178

Barton, R., & Haydn, T. (2015). The impact of a web-based educational resource (the Biomedical Science Electronic Lesson Library) on students' learning experiences in a biomedical science course at a UK university. *Journal of Educational Technology & Society, 18*(1), 100-112.

Barton, R., & Haydn, T. (2015). After the ICT revolution: New challenges for technology in educational research. Research Papers in Education, 30(2), 169-199.

Bryan, J. (2006). Video analysis software and the investigation of the conservation of mechanical energy. *Contemporary Issues in Technology and Teacher Education [Online serial]*, 4(3). http://www.citejournal.org/vol4/iss3/science/article1.cfm.

Chen, C. H., Wang, Y. H., & Chen, S. Y. (2015). Promoting students' scientific literacy through inquiry-based learning in Taiwanese elementary science classrooms. *International Journal of Science Education, 37*(4), 632-654.

Chen, C. M., Huang, S. H., & Chang, W. H. (2015). Comparing the effects of mobile-assisted and traditional problem-based learning approaches in a nursing ethics education course. Nursing Ethics, 22(7), 852-862.

Chi Jung Sul, Hsin-Cheb Chen, Ping-Han Cheng & Chun-Yen C.Y. Chang (2022). The Go-Lab platform, an Inquiry Learning Space: Investigation into students' technology acceptance, knowledge, integration and learning outcomes. *Journal of Science Education and Technology*,. *32* (1) 1-17. DOI:10.1007/S10956.022-10008-X

Croak, M. (2018). STEM education and its impact on productivity: A literature review. Research in Science & Technological Education, 36(3), 301-316.. https://digitalworks.union.edu/theses/1705

Ertikanto, C., Herpratiwi, Yunarti, T., & Saputra, A. (2017). Development and evaluation of a model-supported scientific inquiry training program for elementary teachers in Indonesia. *International Journal of Instruction, 10* (3), 93–108. https://doi.org/10.12973/iji.2017.1037a

Ertikanto, C., Herpratiwi, H., Yunarti, T., & Saputra, A. R. (2017). STEM-oriented learning in junior high school: An inquiry-based learning approach. Advanced Science Letters, 23(4), 3091-3094.

Graham, T., & Rowlands, S. (2000). Using computer software in the teaching of mechanics. *International Journal of Mathematical Education in Science and Technology*, 31(4), 479-493.

Gnesdilow, D., & Puntambekar, S. (2021). The impact of instructional prompts and learning progressions on student science learning in inquiry-based virtual labs. Computers & Education, 175, 104392.

Isseks, Marc. (2011). When teachers reduce curriculum content to bullet points, student learning suffers. *Educational Leardership*, 74–76.

Jeon, A. J., Kellogg, D., Khan, M. A., & Tucker-Kellogg, G. (2021). Developing critical thinking in STEM education through inquiry-based writing in the laboratory classroom. *Biochemistry and Molecular Biology Education, 49*(1), 140–150. https://doi.org/10.1002/bmb.21414

Jeon, S., Kellogg, M., Khan, S., & Tucker-Kellogg, G. (2021). Inquiry-based learning to promote student engagement in bioengineering. In Proceedings of the 8th International Conference on Learning Sciences (pp. 703-706). International Society of the Learning Sciences.

Johnson, Karen and Golombek, Paula. (2016). *Mindful L2 Teacher Education: A sociocultural perspective on cultivating teacher's professional development*. New York: Routledge.

Jong, M. S. Y., Rodríguez-Triana, M. J., Hovardas, T., Dikke, D., Doran, R., Dziabenko, O., Koslowsky, J., Korventausta, J., Law, N. W. Y., Pedaste, M., Tasiopoulou, E., Vidal, N. N., & Zacharia, Z. C. (2021). The impact of training in the use of inquiry learning space (ILS) and Go-Lab on the attitude of teachers and students towards the use of ILS in Nigerian schools. *Journal of Educational Technology & Society*, *24*(1), 175-189. DOI: 10.17706/jets.24.1.175-189

Jong, T. de, Gillet, D., Rodríguez-Triana, M. J., Hovardas, T., Dikke, D., Doran, R., Dziabenko, O., Koslowsky, J., Korventausta, M., Law, E., Pedaste, M., Tasiopoulou, E., Vidal, G., & Zacharia, Z. C. (2021). Understanding teacher design practices for digital inquiry-based science learning: the case of Go-Lab. In Educational technology research and development : ETR & D (pp. 1–28). https://doi.org/10.1007/s11423-020-09904-

Jong, T., Rodríguez-Triana, M. J., Hovardas, T., Dikke, D., Dziabenko, O., Koslowsky, M., Korventausta, J., Law, N., Pedaste, M., Tasiopoulou, E., Vidal, N., & Zacharia, Z. C. (2021). Inquiry learning. In The SAGE Encyclopedia of Educational Technology (pp. 693-695). SAGE Publications.

Jung, S., Hsin-Cheb, L., Cheng, J., & Chun-Yen, C. (2022). Effects of an inquiry-based learning environment on high and low knowledge integration students' learning performance and technology acceptance. Interactive Learning Environments, 30(2), 162-176.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2018). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75-86.

Kirschner, P. A., Karpinski, A. C., & Miao, Y. (2018). 10 years later: What do we know about the effects of what instructional designers do (and don't do)? British Journal of Educational Technology, 49(6), 1048-1058.

Lee, M. H., & Lee, H. S. (2015). The effects of inquiry-based learning on elementary students' science process skills and science attitudes. *Journal of the Korean Association for Science Education, 35*(6), 1166-1176.

Lee, K., & Lee, W. (2015). Analysis of the factors influencing technology adoption by Korean teachers: Application of the UTAUT model to a Korean sample. Computers & Education, 85, 54-61.

Liu, C. C., Tsai, M. F., & Paas, F. (2018). Exploring the factors influencing the adoption of inquiry-based learning in science education. *Educational Research Review, 25*, 1-18.

Liu, S. H., Liao, H. L., & Pratt, J. A. (2018). Impact of media richness and flow on e- learning technology acceptance. Computers & Education, 126, 205-214.

Marginson, Simon, Russel Tytler, Brigid Freeman & Kelly Roberts (2013). 'STEM: Country comparisons: International Comparisons of science, Technology, Engineering and Mathematics (STEM) Education' *Australian Council of learned Academies*: 1-178

Oyin (June, 2021). The impact of technology on our educational system. http://www.superprof.ng>education

Oyin, S. O. (2021). Impact of technology on education in Nigeria. Nigerian Journal of Educational Technology, 40(1), 1-10.

Rios, J., &Madhavan, S. (2000). Guide to adopting technology in the physics classroom. *The Physics Teacher*, 38, 94-97.

Sánchez A. B. , Mena J , Gonzalez M & GuanLin H (2012). In Service Teachers' Attitudes towards the Use of ICT in the Classroom *Procedia - Social and Behavioral Sciences* 46, 1358-1368. DOI: 10.1016/j.sbspro.2012.05.302

Sanchez, J., Barrantes, M. C., & Huertas, A. (2012). Attitude towards ICT and educational innovation in university teachers. Computers & Education, 58(1), 843-855.

Song, H., Yang, S., Zhang, Y., & Liu, Y. (2020). Training in teaching materials development: An investigation into EFL teachers' attitudes and behavior changes. Frontiers in Psychology, 11, 793.

Tiryakioglu, Filiz and Erzurum, Funda. (2011). Use of social networks as an educational tool. *Contemporary Educational Technology*, *2*(2), 135–150.

Uswatun, Hasanah., I Made, Astra., & Mohamad Syarif Sumantri (2023). Exploring the Need for Using Science Learning Multimedia to Improve Critical Thinking Elementary School Students: Teacher Perception. *International Journal of Instruction 16* (1) 417-440

Westera, Wim. (2015). Reframing the role of educational media technologies. *Quarterly Review of Distance Education*, 16(2), 19–32.