Journal of Teaching and Learning

The Effect of Gender and Teaching Methods on Academic Success in Virtual Reality to Reduce Gender Disparity in Technology

Nicholas Ogbonna Onele and Theresa Chinyere Ogbuanya

Volume 19, Number 2, 2025

URI: https://id.erudit.org/iderudit/1118257ar
DOI: https://doi.org/10.22329/jtl.v19i2.8841

See table of contents

Publisher(s)

University of Windsor

ISSN

1492-1154 (print)
1911-8279 (digital)

Explore this journal

Cite this article

Onele, N. & Ogbuanya, T. (2025). The Effect of Gender and Teaching Methods on Academic Success in Virtual Reality to Reduce Gender Disparity in Technology. *Journal of Teaching and Learning*, *19*(2), 5–23. https://doi.org/10.22329/jtl.v19i2.8841

Article abstract

This study adopted a pre-test post-test quasi-experimental design. The sample size was 162 students from eight universities. The sample was categorized into two groups: Group I (n=79) and Group II (n=83). Electric VLab, provided the environment. A researcher-made achievement test, comprising multiple-choice, essay and practical questions was used for assessment and data collection. Two weeks before the treatment, students in both groups were given a pre-test in electronics circuit construction and assembly. Before the treatment, one week was used to train the groups on how to use the Electric VLab. During the treatment, each intact class in Group I was taught using the direct instruction method, and the other classes in Group II were divided into units of five students with a selected peer tutor leading each unit while the teacher coordinated the learning. At the end of treatment, the post-test was administered to both groups. Mean statistics, standard deviation, and analysis of covariance were used to analyze the data. There was no significant difference between the achievement of male students in both groups. Female students in indirect instruction classes achieved significantly higher than their counterparts in direct instruction classes. There were significant effects of interaction between teaching methods and gender.

Journal of Teaching and Learning
Vol. 19, No. 2 (2025), pp. xx–##
https://doi.org 10.22329/jtl.v19i2.8841
www.jtl.uwindsor.ca

The Effect of Gender and Teaching Methods on Academic Success in Virtual Reality to Reduce Gender Disparity in Technology

Nicholas Ogbonna Onele
Ebonyi State University

Theresa Chinyere Ogbuanya
University of Nigeria

Abstract

This study adopted a pre-test post-test quasi-experimental design. The sample size was 162 students from eight universities. The sample was categorized into two groups: Group I (n=79) and Group II (n=83). Electric VLab, provided the environment. A researcher-made achievement test, comprising multiple-choice, essay and practical questions was used for assessment and data collection. Two weeks before the treatment, students in both groups were given a pre-test in electronics circuit construction and assembly. Before the treatment, one week was used to train the groups on how to use the Electric VLab. During the treatment, each intact class in Group I was taught using the direct instruction method, and the other classes in Group II were divided into units of five students with a selected peer tutor leading each unit while the teacher coordinated the learning. At the end of the treatment, the post-test was administered to both groups. Mean statistics, standard deviation, and analysis of covariance were used to analyze the data. There was no significant difference between the achievement of male students in both groups. Female students in indirect instruction classes achieved significantly higher scores than their counterparts in direct instruction classes. There were significant effects of interaction between teaching methods and gender.

Introduction and Background

With every-advancing technological developments, its acceptance and perceived impacts into daily activities are rising progressively. Technology has made life easier and less stressful in every aspect of human existence, resulting in a paradigm shift in the rules of engagement. From entertainment to transportation, health to education, sports to security, updated and evolved information is readily available due to technology. Professionals adopt different technologies that suit their specific needs and the dynamics of their environments (African Development Bank, 2023). The field of teaching and education has greatly benefited from these innovations. The last few decades have witnessed a steady upsurge in the use of technology to improve educational achievements. Recently, universities began to pay attention to educational innovation to enhance teaching and learning through emerging technologies (Hidrogo et al., 2020). In this new era, natural human language is no longer the only method for transmitting information. In addition to the spoken language, other mediums that can convey thoughts and information such as graphics, images, sounds, gestures, symbols, and formulas, are now imperative to teaching and learning (Xue & Wang, 2022). Therefore, classrooms have become increasingly dependent on emerging educational technology tools like computers, tablets, interactive software, and online programs.

Some popular emerging educational technologies that have been found effective in educational fields are virtual reality, blockchain, the Internet of Things and artificial intelligence. Between these, virtual reality (VR) is at a crucial stage of being implemented massively for teaching and learning. Some features of virtual reality which made it a preferred platform for teaching and learning, especially in higher education include: (a) as a technological tool, it can be directly applied to the teaching-learning process; (b) its current technological maturity stage has allowed for the development of hardware and software that can be incorporated into the educational context and the costs have been generally reduced, making its incorporation into the educational context more viable (Onele, 2020); (c) it can boost curiosity among students (Hidrogo et al., 2020); (d) it is easy to implement, and (e) for most students, the university is the only place where they can access this technology (Campos et al., 2022).

Virtual reality is a simulated, three-dimensional, hypermedia setting. Teaching with virtual reality technology encompasses assisting learners to absorb facts through interfaces with a 3D domain, and it has been effectively used to improve teaching and learning in many fields of study (EMBARQ Network 2015; Ogbuanya & Onele, 2018; Phys.org, 2017). The development of virtual reality has made it easier to perform tests that would not otherwise be possible due to the availability, accessibility and cost of equipment, tools, and materials, as well as the safety of human and material resources (Onele, 2020). Although virtual realities were not meant to replace tangible conventional classroom situations, they could enable trainers and students to experiment with safe and precarious practices in computer-generated scenery before they are carried out in the real world of work. Virtual realities have been established to encompass features that arouse and maintain an educational interest in every field of learning, because it can simulate a real environment for training and education, and an imagined environment for interaction (Woodford, 2015). This enables students to work independently, each person at his/her own learning speed, helping students master needed skills, give appropriate feedback, and have the opportunity to correct their mistakes without loss of materials, damage to equipment, or injury to human participants (Katterfeld & Sester, 2012; Onele, 2023).

Virtual reality is capable of simplifying complex and difficult procedures into convenient actions. It aids the visualization of intricate concepts and theories and helps to explore virtual scenarios, while at the same time, motivates interaction by presenting the learning exercise as an entertaining activity. This tool can also help to improve the cost-effectiveness of teaching and learning without plummeting educational outcomes (Taylor-Nelms & Hill, 2014). Virtual reality encourages participation, reduces distractions, and sustains students' attention spans (Onele, 2023). With VR, learning may become more interactive, playful, and experimental, resulting in action-oriented learning.

The inclination of young people of university age to use mobile devices, such as computers, tablets, and cellular phones, could give credibility to the espousal of virtual reality as an instructive device (Ogbuanya & Onele, 2018; UNESCO, 2012). According to Coughlan (2013), young people are expected to read more on computer screens, rather than in printed books. Hu-Au and Lee, (2017) found that male and female youths from diverse backgrounds were interested in computer-based learning platforms. About 92% of teens were online daily, playing games, live streaming memorable experiences, sharing ephemeral moments, or posting pictures of exciting daily occurrences on Instagram, Facebook, Twitter, Snapchat, etc., using computers, tablets, and mobile phones (Wadhera, 2016). Findings estimated that about half of all households had at least one computer, up from just above a quarter in 2005 (International Telecommunication Union 2018), and 63 % of the world population has access to the internet in their homes (International Telecommunication Union 2021). Furthermore, about 96% of the global population now live within reach of a mobile cellular network and 90% can access the internet through a 3G or higher speed network (Banica et al., 2017). The pervasiveness and level of information communication technological tools adaptation suggest that virtual reality will receive maximum acceptance by the age group of university undergraduates.

Although other forms of VR exist, two major types of virtual reality can be adopted in the classroom. The first approach is the complete immersive system, presented on multiple, room-size monitors or through a stereoscopic, head-mounted display component (Strickland, 2016). Immersive virtual reality requires specialized supplementary equipment, such as a data glove and head-mounted devices, to enable participants to navigate the virtual environment with normal human body actions. Sensors on the head unit and data gloves track the viewer's movements during exploration and provide feedback. This environment may be a series of large screens or a complete cave automatic virtual reality system (Virtual Reality Society, 2016). Although immersive virtual reality is judged safe and effective for educational purposes (Qian et al., 2020), some studies reported specific health and safety challenges in the extensive use of immersive virtual reality. There were reports of motion sickness, simulator sickness, and perceptual shift in its users (Nelson, 2014). Some people were found to suffer seizures, imbalance, and a level of psychological nervousness, due to the wearing of headsets for a long time (Feodoroff et al., 2019; Tychsen & Foeller, 2020). Women were also reported to have manifested a greater VR-induced motion sickness than men (Miehlbradt et al., 2021).

The second virtual reality that can be used for educational purposes is the conventional desktop set-up, called a desktop, fish tank (Onyesolu & Eze, 2011) or simply a non-immersive virtual reality. Desktop virtual reality is presented on an ordinary computer screen and is usually explored by a keyboard, mouse, wand, joystick, or touch screen (Friena & Ott, 2015; Onele, 2020). This format is more affordable than immersive virtual reality, making it appropriate for studies in low, medium, and high-income economies. Moreover, no proof exists that immersive virtual reality is more effective in educational applications than its non-immersive counterparts (Strickland, 2016). Rather, there were shreds of evidence that non-immersive virtual reality is much more mature and widely used in different educational areas than immersive virtual reality, which is bulky, costly, and occupies much space (Ogbuanya & Onele, 2018). Studies have shown that desktop virtual reality technology can enhance academic achievement (Aoki et al., 2007) and reduce gender inequality in education (Onele, 2023). This tool seems established, simple, and can be used for different training programs. It is, therefore, safer to experiment with desktop virtual reality, especially in Africa, where research in VR is low. Desktop virtual reality seems secure and easily accessible. Woodford (2015) found that this type of VR is more collaborative than its immersive counterpart. Aside from the greater effect of VR-induced motion sickness (Miehlbradt et al., 2021), women found desktop VR easier and safer to use ((Stanney et al., 2020; Kelly et al., 2023).

Literature Review

Desktop virtual reality may have existed for decades, however, its use is new to education in some parts of the world, like sub-Saharan Africa. Such a situation presents challenges and opportunities for instructors and researchers interested in virtual reality technology. One of these was selecting the right principles, pedagogical, and classroom management strategies when teaching in virtual reality. Studies on teaching methods have recently been on the increase. Some of these were on how to arrange lessons, how these arrangements affect students' behaviours, and in the long term, how they affect students' academic achievement. At the same time, there is an insufficient, inconclusive, and lacking prescriptive body of research to guide instructional methods and classroom facilitation of virtual reality technologies (Ausburn & Ausburn, 2008; Christou, 2010; Hanson & Shelton, 2008; Paszkiewicz et al., 2021). Researchers observed a dearth of empirical evidence to help instructors choose the right teaching methods in virtual reality (Chen et al., 2005; Kim et al., 2023; Sköld, 2012). Erawati et al. (2021) found that more than half (60%) of the teachers faced difficulties determining appropriate digital learning methods. Many studies about the use of VR in education have focused on students' learning outcomes, motivation, and attitude (Arici et al., 2019). The literature may not have reported significant differences in learning outcomes, when comparing pedagogical methods in virtual reality learning experiences. Thus, academics interested in classroom application of virtual reality technologies did not have either a sound theoretical framework or a strong body of empirical data from controlled experiments with which to work. Researchers believe that virtual reality as a learning environment will require thorough pedagogical theory trials by educators, in order to choose the most appropriate and suitable teaching methods, especially for teaching and learning in the field of technological education (Anderson 2008; Häfner et al., 2013).

Although the planning and selection of course content are important (Onele, 2014), the right teaching method could help to determine the success of achieving educational objectives (Isa et al., 2020). In different fields, some teaching methods may be more effective than others. Instructors have adopted different teaching methods for teaching and learning technological education in conventional classrooms (Florentino, 2010; Ormrod, 2012). Some methods include the lecture method, direct instructional method, question and answer method, project method (Bakare, 2011), field trip, exploration method, discussion method, recitation, seminars (Doliente, 2014), problem-solving, concept mapping, indirect instruction (Idris & Rajudin, 2012), discovery, inquiry, and internships, among others (Airth, 2016; Howard, 2014). According to Rüütmann & Kipper (2011), all teaching methods fall under direct and indirect instruction.

In direct instructional classes, the teacher tells the students what to do, how to do it, and when it needs to be done. The teacher imparts information to the students via lectures, assigned readings, audio/visual presentations, direct instructions, role-playing, and other means. Students gain information primarily by listening, taking notes, doing role plays, and practising what they are told to do. The learners only respond with 'yes or no' when the instructor asks, 'Do you understand?' Direct instruction is widely used in teaching and recommended for technology-related courses (Ruutmann & Kipper, 2011). It facilitates students' understanding of the material by removing any potential for misunderstanding. Instructors who use direct instruction could have a superior grip on their student's strengths and weaknesses, and direct instruction enables them to adjust their teaching to the specific needs of their students (Sudirman et al., 2023). Conversely, indirect instruction is an approach to teaching and learning in which concepts, patterns, and abstractions are taught in line with concept learning, inquiry learning, and problem-centred learning (Ruutmann & Kipper, 2011; Porter, et al 2014). In indirect instruction, the teacher provides the learning materials and the specific role changes from presenter to one of a facilitator, support or resource person, and evaluator, as necessary. The instructor becomes a facilitator, rather than a presenter, as obtained in the direct instructional method. Indirect instruction provides flexibility for the students to explore diverse learning activities and fosters creativity and the development of interpersonal skills. It allows the students to participate through technology or role-playing activities (Austin Peay State University, 2023).

Methods adopted for teaching could affect the educational achievement of learners (Duruji et al., 2014) Some teaching methods may lead to low levels of student engagement and result in low academic achievements (Ayodele & Yusuf, 2012; Inayat & Ali, 2020). Identification of effective teaching methods requires information not only on the natural variables arranged during instruction (e.g., materials, teacher behaviour) and academic outcomes (e.g., achievement tests), but also on the processes that can influence the rate of students' responses (e.g., interest) (Ayodele & Yusuf, 2012), as well as consideration of gender uniqueness in learning. Idris and Rajuddin (2012) found a significant difference between the achievement of male and female technology students with regard to teaching methods. Some researchers reported a cognitive difference between men and women, indicating that men learn differently from their female counterparts (Goldman, 2017; Määttä & Uusiautti, 2020; Xin et al., 2019), especially in technological areas. This has led to gender disparity in technology education (Campos & Scherer, 2024). Although gender equality and non-discrimination have been critical concerns in schooling, gender-related divisions continue to occur in the field of technology and technology-oriented fields are still mostly male-dominated (Niiranen, 2017). Boys enjoy and respond better to learning situations that involve active physical activity (UNDP, 2014), while girls learn better and thrive in connection and relationships (Osarenren-Osaghae, et al 2019). Therefore, methods for conventional classroom learning should be examined before they can be applied to virtual reality (Carr et al., 2010; Santilli, 2025; Sheehy, 2010; Shin, & Ocansey, 2018).

Mallick (2018) suggested that teacher-centred methods, such as direct instruction, will be more effective than the student-centred mechanism. Briggs (2013) maintained that the direct instructional teaching method can produce high levels of student participation and correct responses and could hold students' attention. Contingency and rules of direct instructional methods in virtual reality may lead to gains in task and work behaviours that increase academic outcomes (Alam & Mohanty, 2023. The direct instructional method was recommended by researchers for the teaching of technical subjects, like electronics technology education (Keesee, 2016*).* Naboth-Odums (2014) argued that the student-centred approach to instruction, such as tutoring, would be more effective. Substantial research on the effectiveness of teaching methods indicates that the quality of teaching is often reflected by learners' academic achievements (Paszkiewicz et al., 2021). Therefore, the direct and indirect instructional methods, which are dominantly used in some universities, and indirect instruction, a student-centred method fast gaining ground in teaching and learning situations, were compared in virtual reality.

Theoretical Framework

Three theories guided this study, including the theory of constructivism, experiential learning and the social interdependence. The first theory, constructivism, developed by Jean Piaget in 1967, proposed that learning is a dynamic process comprising successive stages of adaptation to reality during which learners construct knowledge by creating and testing their theories of the world. Constructivism requires that a more experienced individual demonstrates the process of problem-solving before learners. This is the basis of the demonstration method of teaching used in this study, where the more experienced person in the classroom is the teacher (Ni, 2022). Experiential learning emphasizes learning by doing, which the virtual reality learning environment provides. It maintains that experiences come by practice with reality and the experienced should lead the inexperienced, such as the teacher-led demonstration teaching method (Marougkas et al., 2023). However, the theory of social interdependence states that learning comes from forming groups and sharing ideas from experiences. Positive interdependence exists when individuals perceive that they can reach their goals, if, and only if, the other individuals with whom they are cooperatively linked also reach their goals, and, therefore, promote each other's efforts to achieve their goals (Shimizu et al., 2020). Social interdependence espoused the importance of the small homogenous group to learning, which favoured peer tutoring as chosen for this study. The following hypotheses were formulated to guide this quasi-experimental study:

1. There is no significant difference between the mean academic achievement scores of the university students who were taught in virtual reality with the direct instructional method and those who were taught in virtual reality with the indirect instructional method.
2. There is a significant interaction effect of gender and teaching methods on the mean academic achievement scores of university students who were taught with the direct instructional method and those taught by the indirect instructional method.

Research Design

This research adopted a pre-test, post-test quasi-experimental design. This design is appropriate for the study since intact classes were used and no randomization was done in the selection of participants.

Participants:

All 300-level students in the eight selected universities were used and treated as intact classes. The sample was categorized into two groups of four universities each: Group One (n=79) and Group Two (n=83). All students were to learn circuit construction for the first time and were assumed to have the same background.

Methodology:

This study was completed in fourteen weeks. Two weeks before the treatment, students in both groups were given a pre-test in electronics circuit construction and assembly. This was done by administering the two instruments for data collection to the students. One week was used to train the groups on how to use the ElectricVLab software program and another week was used to train the facilitators (peer tutors and demonstrators). Four modules were covered in this study: design of electronic circuits, electronics circuit assembly, testing, and safety precautions. Both groups received ElectricVLab. Each class in group one was taught electronic circuit construction by their course lecturer (demonstrator/teacher), using direct instruction (demonstration method). The teacher carried out what the students were expected to do, while the students followed through with guided practice. During class practice and questioning, each student worked independently.

However, classes in group two were classified into peer groups of five students each, with one student as leader and a peer tutor in each group. There were 15 groups and eight clusters in group two. A peer tutor (student leader) led each group, while the teacher facilitated the entire class and went around occasionally to validate what each group did. The teacher mentioned the task to be carried out and each group worked together to get it done. During class practice and questioning, students worked in groups and then in clusters. The study took about two hours for each contact and was held once a week at the same time at all eight universities (Wednesdays 10 am-12 noon) for ten weeks. After the treatment, the students were given the post-test. The pre-test and post-test were similar in content, with a reversed order of the questions to avoid a set response effect. A gap of eleven weeks between the pre-test and the post-test was for teaching and to reduce the pre-test sensitization threat. Since the two groups differed in population, a one-sample t-test was used to establish the homogeneity of members in the two learning groups. The result showed that the groups were homogenous in terms of their previous knowledge, measured by the pre-test. Students were not given prior information on the dates for each pre-test and post-test.

Extraneous variables were controlled by standardization of procedures and instructions, ensuring that in every step of the experimental procedures, all participants were treated in the same way. The researcher ensured that the same experimental conditions were given to both groups and that all the classes and examinations took place simultaneously (8 am -12 noon on Wednesdays). To control the extraneous variable, both groups of learners had to have the same experimental setting (Pourhoseingholi et al., 2012; Wunsch, 2007). The same software was used, the same type of computer was given to all the participants, and the classroom setting was the same. After 19 weeks of the experiment, one day per week (Wednesday), for two weeks, was used for data collection. The instrument for data collection was a researcher-made achievement test which comprised 20 multiple-choice questions, six essays and three alternatives to practical questions. The achievement test items were tested for content, reliability (0.71) and difficulty index (between 40 and 61) by test and subject experts. On the first day, the instrument for data collection, (written examination) was administered. Two hours were used for the examination in each institution. Students' levels of achievement in the test was used as their academic achievement. In the second week, the participants were asked to construct a 9V power supply using capacitors, resistors, and inductors as filters. Both theory and practical works were scored and used for analysis.

***Method of Analysis*:**

Research questions were answered using descriptive statistics in order to analyze the estimated marginal means and standard deviation. A two-way analysis of covariance (ANCOVA) was used to test the four hypotheses at a 0.05 significant level. Analyses of Covariance further helped to control extraneous variables, which reduced the initial differences between groups, due to the lack of randomization, and made compensating the adjustments to the data (Ganyaupfu, 2013; Karpen, 2017; Lakens & Caldwell, 2021; Shieh, 2020) more reliable. In the results where significant differences were observed, the Duncan post hoc test was applied to examine the sources of difference.

Findings

Table 1: Combined academic achievement scores of groups.

Descriptive Statistics

Studied Groups	Group	Pretest Mean	Post Test Mean	Std. Deviation	N
Direct instruction class	1	15.21	70.47	9.75	79
Indirect instruction class	2	14.98	76.38	8.93	83
	Total	15.10	73.96	9.27	162

Table 1 shows that the students in the direct instruction class had a mean achievement score of 70.47% and a standard deviation of 9.75. Students in the indirect instruction class had a mean achievement score of 76.38% and a standard deviation of 8.93. This demonstrates that the indirect instruction class achieved slightly higher results than the direct instruction class. The direct instruction class had a higher standard deviation, suggesting that their score was wider apart than the indirect instruction class.

Table 2: Mean and standard deviation of academic achievement scores of male and female students.

Dependent Variable: Post-Test of Students' Academic Achievement

Studied Variables	Gender in each group	Pretest Mean	Post Test Mean	Std. Deviation	N
Direct instruction class	Females	14.91	64.7500	8.73008	28
	Males	15.11	72.2308	9.63040	51
	Total	15.21	70.4706	9.83881	79
Indirect instruction class	Females	15.02	73.2833	9.57704	26
	Males	14.80	73.5185	8.87681	57
	Total	14.98	76.3846	8.97252	83
	Total	15.10	73.9589	9.36916	162

Table 2 shows that female students in the direct instruction class had a mean score of 64.75% with a standard deviation of 8.73, while male students in the direct instruction class had a mean score of 72.23% with a standard deviation of 9.63. Furthermore, female students in the indirect instruction class had a mean score of 73.28% with a standard deviation of 9.58 and male students in the indirect instruction class had a mean score of 73.52% with a standard deviation of 8.88. This implies that female students in the direct instruction class had the lowest mean achievement score and the least dispersion in their score, as indicated by the lowest standard deviation.

Table 3: Mean academic achievement scores of male and female students.

Academic Achievement Scores			
Gender	Direct instruction	Indirect instruction	Variance
Male	72.2308	73.5185	0.2877
Female	64.7500	73.2833	7.5333
Variance	7.4808	0.2352	

Table 3 shows that the mean difference in the academic achievement of male and female students in the direct instruction class is 7.48, and the mean achievement of male and female students in the indirect instruction differed by 0.24. Moreover, male students in direct instruction and those in indirect instruction differed by 0.29, while female students in indirect instruction and female students in direct instruction classes differed by 7.53. The results implicate that the difference between the mean achievement scores of female students in direct instruction classes and female students in indirect instruction is significantly high.

Table 4: Summary of the analysis of covariance (ANCOVA) test of significance between the mean academic achievement score of groups and gender.

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	410.474	3	136.825	1.598	.198	.065
Intercept	279351.158	1	279351.158	3261.586	.000	.979
Groups	343.929	3	171.964	3.347	.142	.155
Gen	1556.640	1	1556.640	84.603	.001	.451
Grp * Gen	1264.290	1	1264.290	68.714	.001	.412
Error	5909.773	158	85.649			
Total	379443.000	162				
Corrected Total	19925.741	161				

a. R Squared = .905 (Adjusted R Squared = .901)

The result in Table 4 indicates that groups had a calculated p-value of 0.14. This figure is higher than the threshold level significance level ($p < 0.05$) and a partial eta squared of 155. This signifies that there was no significant difference between the mean academic achievement of students in direct instruction classes and students taught with indirect instruction classes in universities. Therefore, the null hypothesis of no significant difference between the academic achievement of students in electronic technology who were studied in virtual reality with the direct instructional method and those taught with indirect instruction was accepted. The result also indicated a partial eta squared of 0.07. This shows moderate effects of the teaching methods, and that only about 7% of the academic achievement of electronics technology education students in the universities was attributable to the teaching methods. However, gender designated a calculated p-value of 0.001, which is lower than the threshold of significance ($p < 0.05$) and a partial eta squared of 451. This indicates a significant difference between the academic achievement of males and that of female students. It also shows that about 45% of the increase in academic achievement of students was due to treatment. On the other hand, the interaction between group and gender showed a calculated p-value of 0.001, which is lower than the threshold of significance ($p < 0.05$) and a partial eta squared of 412. This result indicates that there was a significant difference in the academic achievement of students and that 41% of the difference can be credited to the interaction between gender and groups.

Table 5: Post hoc test of students' academic achievement scores.

	Gender in each group	N	Subset 1	Subset 2
Duncan	Females in a direct instructional class	28	64.7500	
	Females in an indirect instructional class	26		73.2833
	Males in a direct instructional class	51		72.2308
	Males in an indirect instructional class	57		73.5185
	Sig.		1.000	.908

Table 5 indicates no significant difference in the mean academic achievement difference between female students in indirect instruction classes, male students in direct instruction classes, and male students in indirect instruction classes. However, there was a significant difference between the mean academic achievements of female students in the direct instruction class and the other three groups. This shows that female students in direct instruction classes are the source of significant differences in the mean academic achievement of male and female students in the groups.

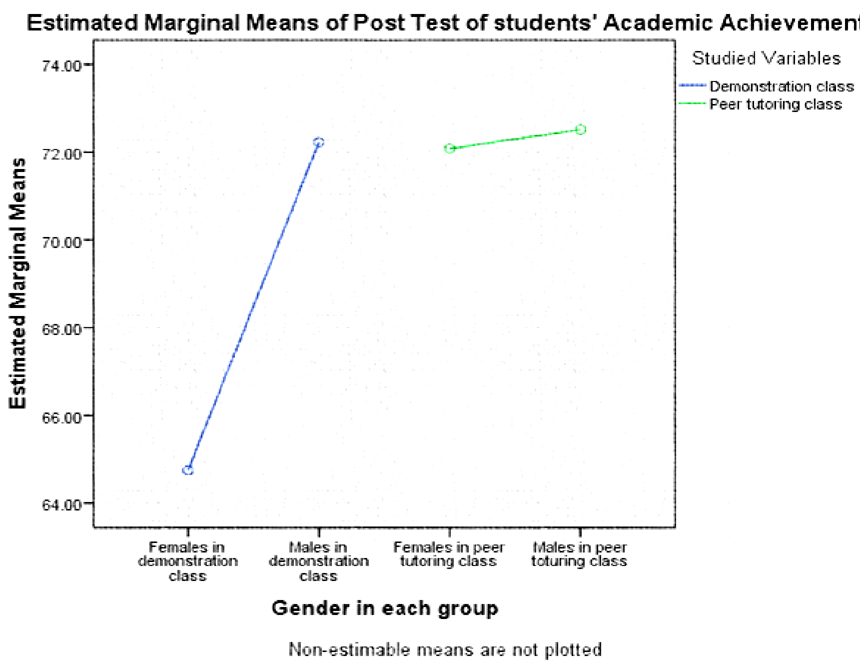

Figure 1: Interaction effect of gender and teaching methods on academic achievement scores.

Figure 1 shows that the lines of direct and indirect instructions were not parallel, indicating a significant interaction effect between gender and teaching methods. However, the lines did not cross each other, suggesting that the interaction effect is not disordinal but ordinal. Males and females demonstrated relatively equal levels of achievement in indirect instruction classes (M = 73.5; F= 73.3). Males achieved more than females in the direct instruction class (72.2> 64.8). This indicates a significant ordinal interaction between gender and teaching methods in virtual reality for the teaching and learning of electronic technology in universities. As a result, the null hypothesis of no significant interaction effect of gender and teaching methods on the academic achievement of electronics technology students taught in virtual reality in universities was rejected.

Discussion

The findings of this study show that students recorded high educational achievements in electronics technology when the course was taught in virtual reality. This indicates that virtual reality is an educational tool that could enhance learning. It, therefore, agrees with Gannon (2014) that virtual reality can increase students' academic achievement in technology and industrial arts. This result was also consistent with the findings of Lee et al. (2009) and Moazami et al. (2014), who cite that those experiments which involve hands-on and minds-on activities in which students could actively be involved in the learning process can be enhanced by computer-assisted learning, such as virtual reality. However, some research findings showed no significant advantage of using virtual reality-based learning on students' achievement as in the study of Snyder et al. (2011) and Chatfield (2014). This variance could result from the level of equipment in the areas where these studies were carried out. Some physical laboratories in the developed countries of these studies were probably equipped with adequate modern educational facilities. In such an ideal situation, virtual reality would not be more effective than the conventional classroom setting. However, most universities in developing countries lack adequate facilities for optimum laboratory practice (Chikafalimani, et al, 2021). Although some researchers believe that to build accurate representations of reality, create consensual meanings in social activities, or personally coherent models of realities, experience is still paramount. However, the experience would be effective if the facilities available for teaching and learning were enough to achieve the desired educational goal. This study was carried out in universities where their equipment was rated high for the study of electronics technology (National Universities Commission, 2016). However, these highly-rated institutions lacked basic teaching facilities compared to international standards. Therefore, an unconventional way of providing effective instruction within universities, such as VR technology, might be considered.

Although the direct instruction teaching method showed some improvement, students in indirect instruction classes achieved higher results. This indicates that indirect instruction could yield higher results in virtual reality. There was no significant difference between the mean academic achievement of male students in direct instruction and indirect instruction classes. There was also no significant difference between male and female students in indirect instruction classes. It was revealed that male students in the indirect instruction class achieved slightly higher scored than those in the direct instruction class. However, female students in indirect instruction classes achieved significantly higher than female undergraduates in direct instruction classes. This suggests that female students learn better with indirect instruction, in line with Idris and Rajuddin, (2012), who found a significant difference between the achievement of male and female technology students with regard to teaching methods, as well as Xin et al. (2019) who argued that men learn differently from their female counterparts. This contention is further corroborated by

Goldman (2017), who stated that there was a cognitive difference between men and women. The struggles that some girls may experience in school may be attributed to them feeling lost and isolated, socially, and that they would achieve better academic successes in environments where they can work with others, such as small groups, which are a great setting for girls to learn (Adrift, 2016; Goff, 2018). The prospect for connection, relationships, and small group settings are offered by indirect instruction, as exemplified by peer tutoring.

The fact that female students in the indirect-instruction group achieved significantly higher scores than the female students in the direct instruction group may suggest that the indirect-instruction teaching method is less gender-biased than the direct-instruction teaching method. Although it is congruent with Tomkinso (2021), who revealed that indirect instruction can be effective for both male and female learners in technology, further research is necessary to affirm its consistency. Some studies established that the achievement of male and female students varied with teaching methods in computer-simulated experiments (Choi & Gennaro, 1987; Oladayo & Oladayo, 2012). Therefore, the teaching method adopted in virtual reality might encourage or discourage gender equality in the academic achievement of electronic technology students at universities.

The outcome of this study might have been influenced by students' engagement. This is due to the findings of some researchers who stated that engagement, intelligence, and attention to detail could positively impact academic achievement (Cents-Boonstra et al., 2020; Von Stumm et al., 2011). Furthermore, the study found an interaction between teaching methods and gender. This means that the academic achievement of electronics technology students in universities will depend on the teaching method used in virtual reality. The study further revealed some significant effects of teaching methods as shown by the values of partial eta squared in each situation. The values of partial eta squared ranged between 0.065 and 0.978. Anglim (2011) defined effect sizes as 0.01 for small, 0.06 for medium, and 0.1 for large, while Lenhard and Lenhard (2016) categorized effects as <0 for adverse, 0.003 for no effect, 0.039 for small, 0.110 for intermediate, and 0.140 and above for large. Similarly, Hattie (2009) stated that effect sizes of 0.140 and above are attributable to specific interventions or methods being researched and that such changes are beyond natural maturation or chance.

Conclusion and Implications

The results of this study supported the previous findings that indicate how virtual reality could improve the academic achievement and interest of electronics technology students in Nigerian universities. This research is cutting-edge for virtual reality research in Nigerian universities. Moreover, these results have contributed to the limited empirical findings on comparing direct instruction and indirect instructional methods of teaching and learning. It revealed no significant difference between the mean academic achievement of male students in direct instruction and indirect instruction classes. There was also no significant difference between male and female students in indirect instruction classes. However, it did show that students in the indirect instruction class achieved slightly higher scores than those in the direct instruction class. The female students in indirect instruction classes achieved significantly higher than their female counterparts in direct instruction classes. In this investigation, female students in the indirect instruction group not only achieved higher scores than their counterparts in the direct instruction group, but indicated a higher interest in electronics technology in universities that use virtual reality. The study, therefore, revealed that the indirect instructional method, in virtual reality, creates gender equality in the study of electronic technology in universities. This study was limited to comparing direct and indirect instructional methods, particularly, demonstration and peer tutoring instructional methods. Many other methods were not covered. Therefore, researchers might wish to compare additional methods to discover effective instructional methods for virtual reality.

Acknowledgements

The researchers are thankful to Quality Assurance International, LLC, Massachusetts, United States of America, for supplying the virtual reality software used in this study at no cost to the researchers.

Author Bios

Nicholas Ogbonna Onele is a lecturer, mentor, and researcher in the Department of Technology and Vocational Education at Ebonyi State University, Nigeria. His research focuses on skill acquisition, learning environments, educational inequality, teaching and learning, and pedagogy.

Theresa Chinyere Ogbuanya is a professor of Industrial Technical Education at the University of Nigeria, Nsukka. She is interested in educational equality, social justice, and technical and vocational education and training (TVET).

References

African Development Bank (2023). *ICT financing needs and trends*. Abidjan: The Infrastructure Consortium for Africa.

Airth, M. (2016). *Indirect instruction: Definition and strategies.* http://study.com/academy/lesson/indirect-instruction-definition-strategies.html

Alam, A., & Mohanty, A. (2023). Implications of virtual reality (VR) for school teachers and instructional designers: An empirical investigation. *Cogent Education*, *10*(2) 1-22. doi.org/10.1080/2331186X.2023.2260676

Anderson, C. (2008). *Virtual world webquests: Principle elements of research supported learning experiences within virtual learning environments.* Lulu. http://www.lulu.com/content/2287172.

Anglim, J. (2011, September 23). *How to interpret and report eta squared/partial eta squared in statistically significant and non-significant analyses* [Online forum comment]. https://stats.stackexchange.com/questions/15958/how-to-interpret-andreport-eta-squared-partial-eta-squared-in-statistically

Aoki, H., Oman, C. M., Buckland, D. A., & Natapoff, A. (2007). *Desktop-VR system for preflight 3D navigation training*. Acta Astronautica. doi:10.1016/j.actaastro.2007.11.001

Arici, F., Yildirim, P., Caliklar, Ş., & Yilmaz, R. M. (2019). Research trends in the use of augmented reality in science education: Content and bibliometric mapping analysis. *Computers & Education*, *142*, 103647

Ausburn, L. J., & Ausburn, F. B. (2008). New desktop virtual reality technology in technical education. *i-manager's Journal of Educational Technology,* 4(4), 48-61.

Austin Peay State University (2023) *Direct and indirect instruction definitions and examples*. Clarksville.

Ayodele, J., & Yusuf Y. (2012). Effect of teaching method, choice of discipline and student-lecturer relationship on academic performance. *Journal of Economics and Sustainable Development,* 3(7), 23-31.

Bakare, T. V. (2011) A consideration of the adequacy of teaching facilities in the universities of the south western zone of Nigeria. *Journal of International Education Research, 7(1),* 89-98.

Banica, l., Burtescu, E., & Enescu, F. (2017). The impact of Internet-Of-Things in higher education. *Scientific Bulletin of Economic Sciences, University of Pitesti*, 16(1), 53-59.

Briggs, S. (2013, Friday, June 7) *How peer teaching improves student learning and 10 ways to encourage it.* http://www.opencolleges.edu.au/informed/features/peer-teaching/#comments

Campos, D.G., & Scherer, R. (2024). Digital gender gaps in students' knowledge, attitudes and skills: An integrative data analysis across 32 Countries. *Educ Inf Technol,* 29, 655–693. https://doi.org/10.1007/s10639-023-12272-9

Campos, E., Hidrogo, I., & Zavala, G. (2022). Impact of virtual reality use on the teaching and learning of vectors. *Frontiers in Education*, *7*. https://doi.org/10.3389/feduc.2022.965640

Carr, D., Oliver, M., & Burn, A. (2010). Learning, teaching and ambiguity in virtual worlds. In A. Peachy, J. Gillen, D. Livingstone, & S. Smith–Robbins (Eds.), *Researching learning in virtual worlds* (pp. 17-331). Springer.

Cents-Boonstra, M., Lichtwarck-Aschoff, A., Denessen, E., Aelterman, N., & Haerens, L. (2020). Fostering student engagement with motivating teaching: An observation study of teacher and student behaviours. *Research Papers in Education*, *36*(6), 754–779. https://doi.org/10.1080/02671522.2020.1767184

Chatfield, T. (2014). *The truth about technology's greatest myth*. http://www.bbc.com/future/story/20140110-technologys-greatest-myth

Chen, C. J., Toh, S. C., & Ismail, W. (2005). Are learning styles relevant to virtual reality? *Journal of Research in Technology in Education, 38*(2), 120-128.

Chikafalimani, S.H.P., Kibwami, N. & Moyo, S. (2021). Management of facilities at public universities in Africa: Current challenges and the way forward. Real Estate Management and Valuation, 29(1), 21-29. https://doi.org/10.2478/remav-2021-0003

Choi, B., & Gennaro, E. (1987). The effectiveness of using computer-simulated experiments on junior high students' understanding of the volume displacement concept. *Journal of Research in Science Teaching, 24*(6), 539-552.

Christou, C. (2010). In A. Tzanavari & N. Tsapatsoulis (Eds.), *Affective, interactive and cognitive methods for E-learning Design: Creating an optimal education experience*. IGI Global

Coughlan, S. (2013, May 16). Young people 'prefer to read on screen.' *BBC News education correspondence*. https://www.bbc.com/news/education-22540408

Doliente, J. P. (2014). *Different teaching approaches and methods*. http://www.principlesofteaching-140403024620-phpapp02

Duruji, M., Azuh, D., Segun, J., Olanrewaju, I. P., & Okorie, U. (2014). Teaching method and assimilation of students in tertiary institutions: A study of Covenant University, Nigeria. *Proceedings of EDULEARN14 Conference 7th-9th July 2014* (Barcelona, Spain).

EMBARQ Network (2015). *Using virtual reality to create safer drivers*. http://www.smartcitiesdive.com/ex/sustainablecitiescollective/friday-fun-using-virtual-reality-create-safer-drivers/1090332/

Erawati, G. A. P. S. A., Widiana, I. W, & Japa, I. G. N. (2021). Elementary school teachers' problems in online learning during the Pandemic. *International Journal of Elementary Education*, 5(4), 562-573.

Feodoroff B, Konstantinidis I. & Froböse I. (2019). Effects of full body exergaming in virtual reality on cardiovascular and muscular parameters: Cross-sectional experiment. *Journal of Medical Internet Research Serious Games,* 7(3), e12324. doi: 10.2196/12324

Florentino, M. (2010). *Principle of teaching: Different teaching approaches and methods*. http://www.slideshare.net/switlu/different-approaches-and-methods

Friena, L., & Ott, M. (2015). *A literature review on immersive virtual reality in education: State of the art and perspectives*. https://www.researchgate.net/publication/280566372

Gannon, M. (2014). Oculus rift: 5 virtual reality uses beyond gaming. http://www.livescience.com/44384-oculus-rift-virtual-reality-uses-beyond-gaming.html

Ganyaupfu, E. M. (2013). Factors influencing academic achievement in quantitative courses among private higher education institutions business students. *Journal of Education and Practice, 4*(15), 57-65.

Goff, S. (2018). *How girls learn differently than boys*. https://theparentcue.org/how-girls-learn-differently-than-boys/

Goldman, B. (2017). *The cognitive differences between men and women.* Stanford Medicine News Center.

Häfner, P., Häfner, V. & Ovtcharova, J. (2013). Teaching methodology for virtual reality practical course in engineering education. *Procedia Computer Science*, 25, 251-260.

Hanson, K., & Shelton, B. E. (2008). Design and development of virtual reality: Analysis of challenges faced by educators. *Educational Technology and Society*, *11*(1), 118-131.

Hattie, J. (2009). *Visible Learning: A Synthesis of over 800 Meta-Analyses Relating to Achievement*. Routledge.

Hidrogo, I., Zambrano, D., Hernandez-de-Menendez, M., & Morales-Menendez, R. (2020). Mostla for engineering education: Part 1 initial results. *Int.J. Interact. Des. Manuf.*, 14, 1429–1441.

Howard, M. (2014). *Direct instruction teaching method: Definition, examples and strategies*. http://study.com/academy/lesson/direct-instruction-teaching-method-definition-examples-strategies.html

Hu-Au, E. & Lee, J. J. (2017). Virtual reality in education: A tool for learning in the experience age. *International Journal of Innovation in Education*, 4(4), 215–226.

Idris, A. & Rajuddin, M. R. (2012). The influence of teaching approaches among technical and vocational education teachers towards the acquisition of technical skills in Kano State-Nigeria. *Journal of Education and Practice,* 3(16), 160-166.

Inayat, A. & Ali, A. Z. (2020). Influence of teaching style on students' engagement, curiosity and exploration in the classroom. *Journal of Education and Educational Development, (*1), 87-102. http://dx.doi.org/10.22555/joeed.v7i1.2736

International Telecommunication Union (2018) Measuring the Information Society Report Volume 1. Geneva: ITU. https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-1-E.pdf

International Telecommunication Union (2021). *ITU datahub*. ICT Data and Analytics Division.

Isa, S. G., Mammam, M. A., Badar, Y. & Bala, T. (2020). The impact of teaching methods on academic performance of secondary school students in Nigeria. *International Journal of Development Research*, 10(7), 37382-37385.

Karpen, S. C. (2017). Misuses of regression and ANCOVA in educational research. *Am J Pharm Educ, 81*(8), 6501.

Katterfeld, C. & Sester, M. (2012) *Desktop virtual reality in E-learning environments.* http://www.isprs.org/proceedings/XXXV/congress/comm6/papers/697.pdf

Keesee, G. S. (2016). *Instructional approaches*. http://teachinglearningresources.pbworks.com/w/pagerevisions/19919560/Instructional%20 Approaches

Kelly, J. W., Gilbert, S. B., Dorneich M. C.& Costabile, K. A. (2023). Gender differences in cybersickness: Clarifying confusion and identifying paths forward. *2023 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops* (Shanghai, China, 2023), 283-288. doi: 10.1109/VRW58643.2023.00067.

Kim, J., Kim, K., Ka, J., & Kim, W. (2023). Teaching methodology for understanding virtual reality and application development in engineering major. *Sustainability*, *15*(3), 2725.

Lakens D & Caldwell A. R. (2021). Simulation-based power analysis for factorial analysis of variance designs. *Advances in Methods and Practices in Psychological Science*, 4(1), 251524592095150. https://doi.org/10.1177/2515245920951503

Lee, E. A., Wong, K. W., & Fung, C. C. (2009). Learning efficiency in a desktop virtual reality-based learning environment In S. C. Kong, H. Ogata, H. C. Arnseth, C. K. K. Chan, T. Hirashima, F. Klett, J. H. M. Lee, C. C. Liu, C. K. Looi, M. Milrad, A. Mitrovic, K. Nakabayashi, S. L. Wong, & S. J. H. Yang (Eds.), *Proceedings of the 17th international conference on computers in education [CDROM*]. Asia-Pacific Society for Computers in Education, 832-839.

Lenhard, W., & Lenhard, A. (2016). *Calculation of effect sizes*. Dettelbach, Psychometrica. https://www.psychometrica.de/effect_size.htm

Määttä K. & Uusiautti S. (2020). Nine contradictory observations about girls' and boys' upbringing and education – The strength-based approach as the way to eliminate the gender gap. *Frontiers of Education, 5*, 134. https://doi.org/10.3389/feduc.2020.00134

Mallick, H. (2018). *What is the direct instructional method of teaching science*? http://www.preservearticles.com/2012041630468/what-is-the-directinstruction-method-of-teaching-science.html

Marougkas A, Troussas C, Krouska A, & Sgouropoulou C. (2023). Virtual reality in education: A review of learning theories, approaches, and methodologies for the last decade. *Electronics*, 12(13), 2832. https://doi.org/10.3390/electronics12132832

Miehlbradt, J., Cuturi, L. F., Zanchi, S., Gori, M. & Micera, M. (2021). Immersive virtual reality interferes with default head–trunk coordination strategies in young children. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-021-96866-8

Moazami, F., Bahrampour, E., Azar, M. R., Jahedi, F., & Moattari, M. (2014). Comparing two methods of education (virtual versus traditional) on learning of Iranian dental students: A post-test only design study. *BMC Medical Education, 14*(45). *http://www.biomedcentral.com/1472-6920/14/45/prepub*

Naboth-Odums, A. (2014). Critical assessment of just-in-time teaching method as against conventional teaching methods on academic performance of business studies students. *Journal of Educational and Social Research, 4(5), 59-66.*

National Universities Commission (2016). *Benchmark of academic standard*. Academic Standard Department.

Nelson, N. (2014). *Virtual reality's next hurdle: Overcoming 'sim sickness'.* http://www.npr.org/sections/alltechconsidered/2014/08/05/338015854/virtual-realitys-next-hurdle-overcoming-sim-sickness

Ni, L. (2022). Learning process through virtual reality: A theory-based application. *Proceedings of the 2022 2nd International Conference on Modern Educational Technology and Social Sciences (ICMETSS 2022)*. https://doi.org/10.2991/978-2-494069-45-9_85

Niiranen, S. (2017). Gender and technology education. In de Vries, M. (Ed.), *Handbook of technology education*. Springer International Handbooks of Education. Springer, Cham. https://doi.org/10.1007/978-3-319-38889-2_61-1

Ogbuanya, T. C. & Onele, N. O., (2018). Investigating the effectiveness of desktop virtual reality for teaching and learning of electrical/electronic technology in universities. *Computers in the Schools*, 35(3), 226-248.

Oladayo, O. T. & Oladayo, C. E. (2012). Effects of direct & indirect instructional strategies on students achievement in mathematics. *African Research Review, 6*(4), 349-361.

Onele, N. O. (2023). The role of desktop virtual reality as an accessible and equitable strategy to improve career opportunities for women in technology. *Journal of Computer Assisted Learning, 39*(1), 20-33.

Onele, N. O. (2020). Virtual reality: A tool for improving the teaching and learning of technology education. *IntechOpen*. http://dx.doi.org/10.5772/intechopen.90809

Onele, N. O. (2014). Planning techniques needed to improve the teaching and learning of basic technology in junior secondary schools in Nigeria. *American Journal of Educational Research, 2*(1)*, 23-28.*

Onyesolu, M.O. & Eze, F.U. (2011). Understanding virtual reality technology: Advances and applications. In Schmidt, M. (Ed.), *Advances in computer science and engineering.* InTech Open Access Publishers.

Osarenren-Osaghae, R. I. Imhangbe1 O. S., & Irabo Q. O. (2019). Relationship between social challenges and the education of the girl-child as perceived by female academics in the tertiary institutions of Edo State, Nigeria. *Educational Research and Reviews,* 14(17), 625-638.

Organisation for Economic Cooperation and Development (2015). *Students, computers and learning – Making the connection*. OECD Publishing.

Ormrod, J. E. (2012). *Essentials of education psychology in cognitive development*. Pearson Education.

Paszkiewicz, A., Salach, M., Dymora, P., Bolanowski, M., Budzik,G., & Kubiak, P. (2021). Methodology of implementing virtual reality in education for industry. *Sustainability, 2021*(13), 5049.

Phys.Org (2017). *Virtual reality training for 'safety-critical' jobs*. https://phys.org/news/2017-03-virtual-reality-safety-critical-jobs.html.

Piaget, J (1967). The mental development of the child. In D. Elkind (Ed.), *Six Psychological Studies*. Vintage Books.

Porter, L., Lee, C. B., Simon, B., & Zingaro, D. (2014). Peer instruction in computing: The value of instructor intervention. *Computers & Education,* 71(February 2014), 87–96.

Pourhoseingholi, M. A., Baghestani, A. R., & Vahedi M. (2012). How to control confounding effects by statistical analysis. *Gastroenterol Hepatol Bed Bench,* 5(2), 79–83.

Qian J, McDonough D. J., & Gao Z. (2020). The effectiveness of virtual reality exercise on individual's physiological, psychological and rehabilitative outcomes: A systematic review. *International Journal on Environmental Research and Public Health, 17*(11), 4133. doi: 10.3390/ijerph17114133

Rüütmann, T., & Kipper, H. (2011). Effective teaching strategies for direct and indirect instruction in teaching engineering implemented at Tallinn University of Technology. *Problems of Education in 21st Century, 36*(2011), 60-75.

Santilli, T., Ceccacci, S., Mengoni, M & Giaconi, C. (2025). Virtual vs. traditional learning in higher education: A systematic review of comparative studies. *Computers & Education, 2*27(2025) 1-31. doi.org/10.1016/j.compedu.2024.105214

Sheehy, K. (2010). Virtual environments: Issues and opportunities for researching inclusive educational practices. In A. Peachey, J. Gillen, D. Livingstone, S. Smith–Robbins (Eds.), *Researching learning in virtual worlds (pp. 1-15)*. Springer.

Shieh G. (2020). Power analysis and sample size planning in ANCOVA designs. *Psychometrika*, 85(1), 101-120.

Shimizu, I., Kikukawa, M., Tada, T., Kimura, T., Duvivier R., & Vleuten C. (2020). Measuring social interdependence in collaborative learning: Instrument development and validation. *BMC Med Educ, 20*, 177 (2020). https://doi.org/10.1186/s12909-020-02088-3

Shin, H., & Ocansey, T. S. (2018). *Stepping into a virtual reality classroom for teacher training.* Centre for Sustainable Development.

Sköld, O. (2012). The effects of virtual space on learning: A literature review. *First Monday*, *17* (1), 1-25.

Snyder, C. W, Vandromme, M. J, Tyra, S. L, Porterfield, J. R. Jr, Clements, R. H, & Hawn, M. T. (2011). Effects of virtual reality simulator training method and observational learning on surgical performance. *World Journal of Surgery, 35*(2), 245-52.

Stanney, K. Fidopiastis C., & Foster, L. (2020). Virtual reality is sexist: But it does not have to be. *Front. Robot, AI* 7, 4. https://doi.org/10.3389/frobt.2020.00004

Strickland, J. (2016). *How virtual reality works*. http://electronics.howstuffworks.com/gadgets/other-gadgets/virtual-reality.htm

Sudirman S., Kennedy D., & Soeharto S. (2023). The teaching of physics at upper secondary school level: A comparative study between Indonesia and Ireland. *Frontiers in Education*, 8, 1118873. https://doi.org/10.3389/feduc.2023.1118873

Taylor-Nelms, L., & Hill, V. (2014). Assessing 3D virtual world disaster training through adult learning theory. *International Journal of Serious Games,* 1(4), 3-16.

Tomkinso, J. (2021). *Work together: The pros and cons of indirect instruction*. Education World. https://www.educationworld.com/teachers/work-together-pros-and-cons-peer-tutoring#google_vignette

Tychsen L, & Foeller P. (2020). Effects of immersive virtual reality headset viewing on young children: Visuomotor function, postural stability, and motion sickness. *American Journal of Ophthalmology,* 209, 151-159. doi: 10.1016/j.ajo.2019.07.020

UNESCO (2012*). Proposed indicators for assessing technical and vocational education and training*. http://www.uis.unesco.org/Library/Documents/TVETIndicators_en.pdf

UNPD (2014). *Gender and poverty reduction*. http://www.undp.org/content/undp/en/home/ourwork/povertyreduction/focus_areas/focus_gender_and_poverty/

Virtual Reality Society (2016). *Virtual reality and ethical issues*. http://www.vrs.org.uk/virtual-reality/ethical-issues.html

Von Stumm, S., Hell, B., & Chamorro-Premuzic, T. (2011). The hungry mind: Intellectual curiosity is the third pillar of academic performance *Perspectives on Psychological Science* 6(6), 574 –588.

Wadhera, M. (2016) The information age is over; welcome to the experience age. *Tech Crunch,* 5(9) 6-11. http://techcrunch.com/2016/05/09/the-information-age-is-over-welcome-to-the-experience-age/

Woodford, C. (2015). *Virtual reality*. http://www.explainthatstuff.com/chris-woodford.html
Wunsch G. (2007). Confounding and control. *Demographic Research, 2007*(16), 97-120.
Xin J, Zhang Y, Tang Y, & Yang Y. (2019). Brain differences between men and women: Evidence from deep learning. *Front. Neurosci*, *13*, 185. doi: 10.3389/fnins.2019.00185
Xue, Y. & Wang, Y. (2022) Artificial intelligence for education and teaching. Wireless *Communications and Mobile Computing,* 2022(6).1-10. doi: 10.1155/2022/4750018