Education and Information Technologies
https://doi.org/10.1007/s10639-023-12414-z

Relative effectiveness of simulation games, blended learning, and interactive multimedia in basic science achievement of varying ability pupils

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Received: 17 May 2023 / Accepted: 27 October 2023

Abstract
The study determined the relative effectiveness of simulation games, blended learning, and interactive multimedia in enhancing learning outcomes in Basic Science of pupils with varying abilities, with a view to providing information on the most effective strategy for instructing Basic Science among pupils with varying abilities. Children should be exposed to and commence learning science at a young age because science and technology are the dynamic forces behind present socioeconomic progress. The research design employed was a quasi-experimental research design. The experiment was conducted in six schools, and two schools were used as the control group. The analysis used descriptive and inferential statistics. Permission was sought from the Local Government Education Authorities (LGEA) to use the schools in their jurisdictions for the experiment. Participants were given a consent form for their parents. Pseudonyms were used to replace participants' names. The findings indicate that interactive multimedia is more effective with pupils in mainstream schools, whereas blended learning proves more effective for pupils in special schools. These findings imply that teachers should employ strategies to captivate and maintain attention while teaching Basic Science.

Keywords Basic science · Mainstream schools · Special schools · Pupils · Varying ability

1 Introduction

Globally, the quantum leap in the development of science and technology is becoming more ubiquitous. It has influenced many facets of a man's work, social life, and many of our pending tasks. As more and more workplaces integrate science

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Published online: 09 January 2024

and technology into their offices, science and technology skills and knowledge are becoming integral to individual and job performance. Technology has fundamentally transformed how businesses operate, including teaching and learning worldwide. This necessitates changes in the teaching and learning process. Recent advancements in pedagogical, didactic, and high-tech advancements have transformed the teaching-learning process (Aktağ, 2015).

Children's science involves teachers and learners researching scientific phenomena. Children are inherently curious about the natural world; therefore, learning about science must be presented in a natural setting. The inquisitive nature of children serves as a powerful motivator for both their work and play. With appropriate supervision and nurturing, children's natural inquisitiveness and need to understand the world enable them to use their ability to investigate and discover fundamental events and objects in the world around them. This can be called one of the first scientific discoveries. (Adeyele & Aladejana, 2019; Ogunseemi et al., 2016). Several factors contribute to the prioritization of science learning in the early classroom years. The first is the growing recognition and knowledge of the importance of early thinking and learning for children. Children have greater learning potential and early childhood institutions should provide an enriching and stimulating environment for learning. Early experiences in childcare settings, guided by qualified teachers, shape their future learning. Also, Science learning is especially crucial in early years as it establishes the groundwork for future scientific comprehension and cultivates essential learning skills and attitudes (Gheith & Al-Shawareb, 2016; Hansson et al., 2021).

Scientific literacy is critical for everyone during this technological age to utilize, cope with, and adjust to the innovations of the time. Nowadays, the science teaching-learning process emphasizes learners' involvement and hands-on activities in a way that is far different from what it used to be. Nevertheless, science teaching and learning at elementary schools are faced with diverse challenges ranging from but not limited to teaching methodology, teaching materials, and the availability of qualified teachers (Awofala et al., 2019). As the technology-driven world continues to evolve, it becomes essential for children to receive enhanced science and technology education in school, ensuring they are well-prepared to acquire a deeper knowledge base in line with the advancements in the technological landscape. Unfortunately, science classes in Nigerian elementary schools do not initially stir learners' interest in science. Several teachers are reluctant to introduce science into their classrooms, often because of their uncomfortable experiences teaching science. When questioned if they tutor science, these teachers can point to plants sketched on the board, pebbles, and various types of sand that are collected outside of the classroom and kept in the science or nature corner, if there is one (Owolabi et al., 2013). Therefore, it is imperative to take decisive action to promote the teaching and learning of science in a manner that enables students to grasp scientific concepts in concrete, tangible, and practical ways. While the traditional method (talk-chalk) may be valid, there are more effective strategies for teaching science at elementary schools. To increase the effectiveness in the classroom, teachers need to embrace innovative strategies for teaching and learning that are hands-on, activity-based, motivating, and sustaining. Using tangible, hands-on materials and familiar occurrences in teaching and learning activities will help learners directly encounter scientific phenomena and motivate them to actively form abstract concepts (Adeyele & Aladejana, 2019).

Simulation games (SG), blended learning (BL), and interactive multimedia (IM) are innovative teaching strategies that are assumed to improve learners' achievement because they are active and instruction based. Activity-based instruction improves the learning of science (Adeyele & Aladejana, 2019; Oblinger, 2006). Science instruction is more engaging and explicit when it is activity-based (Celik & Bayrakcekenp, 2012). Children must find learning engaging since they are naturally curious. Children get bored easily and quickly, so learning should be lively and active to meet their inquisitiveness. Engaging activities that encourage peer interaction enhance learning (Hukriede, 2021). Therefore, this study aims to compare the effectiveness of simulation games, interactive multimedia, and blended learning with traditional teaching methods in basic science.

2 Literature review

2.1 Concept of simulation games, blended learning, interactive multimedia, and varying ability

Simulation games (SG) are designed to portray real-world scenarios (Adeyele & Aladejana, 2018). They depict real-world situations. They are games that imply something exists in a real situation (Chekour et al., 2022; Padilla et al., 2016; Wong et al., 2022). This can be understood as events occurring in reality. Effective learning is through simulations. *"Studying using a simulation is quite different from studying a book, listening to a lecture, or doing a computer drill." " In a scientific discovery simulation, for example, the learner is performing experiments, varying input variables in a systematic fashion, observing and recording output, and (if the simulation is well designed) reflecting on the results."* (Alessi, 2000: 185). Thus, learning through simulation games goes beyond mere activity. It can be viewed as series of tasks alternates between using and creating simulation games to attain different learning goals, with varying levels of effectiveness and depth. (Padilla et al., 2016).

Simulation games are valuable for classroom instruction as they introduce students to complex systems without necessitating their own creation of these games (Padilla et al., 2015). Simulation games help promote learning by offering a safe virtual setting where the learner can interact without worrying about causing danger to life or property (Padilla et al., 2016). Through the utilization of simulation games, students can vividly engage with real, reliable, and fascinating scenarios without ever needing to step out of the classroom. They provide a secure atmosphere free from the consequences of real-world decisions and behaviors, allowing students to experience and comprehend the effects of their actions and choices made. As such, they provide helpful perception into difficult situations that learners might not be directly involved in real life because of the extent of the risk involved, price, or The advantages of using SG as an educational method include learners gaining accurate information, developing social and intellectual skills, and grasping the organization and application of real-world concepts. It can help students learn from their peers and comprehend teachers more clearly. Additionally, it promotes problem-solving in complex situations, experiential learning, and active learning; offers quick and hypothesized feedback; adjusts to the demands of the specific learner while offering support; and is, therefore, learner-centered (Sowunmi & Aladejana, 2016).

Simulation games have been used to teach learners various topics and subjects and was found to improve the teaching-learning process significantly. The value simulation games show in providing concrete connections to learning has been emphasized by research. This is because they stimulate interest, ease tension, maintain focus, sustain attention, and make learning pleasurable (Lean et al., 2021; National Research Council, 2011; Wong et al., 2022). Pooja (2011) and Stoma et al. (2020) assume that when specific instructional goals were targeted, simulation games could successfully pique interest, impart subject knowledge, and support math, physics, and language arts retention. Similarly, simulation games are recognized for their capacity to engage students, enhance interactivity, and bolster critical problem-solving skills, all of which are vital in educational settings. They also help students become more adept at using computers. Research has demonstrated that playing persistent simulation games helps pupils learn scientific concepts (Adeyele & Aladejana, 2019; Akilli, 2006; National Research Council, 2011).

On the other hand, various scholars have provided definitions for blended learning. For example, many have defined blended learning (BL) as combining face-to-face instruction with online learning; others allude to merging face-to-face instruction (Graham, 2006). In many definitions, combining physical classes and e-learning or virtual learning is mentioned. Aladejana (2008) described blended learning as integrating different learning approaches. She believes this can be accomplished by combining in-person instruction with technology-based learning tools. Blended learning is described as combining conventional learning with web-based online approaches. It described it as a blend of tools and media used in an e-learning setting (Nazarenko, 2015; Sharma, 2010). This definition can be fully applicable to online education without any in-person teaching. Blended learning (BL) is the practice of consistently integrating technology into classroom instruction. BL is the practice of regularly incorporating technology into classroom instruction. It combines traditional face-to-face teaching with a learner-controlled online technological component (Giarla, 2016).

Blended learning holds significant importance as it dismantles traditional barriers in education. With the availability of modern technologies, tools, and resources, we can now customize each learner's educational journey. Blended learning permits flexibility in the timetables that may be adjusted for each student and enables them to go at their own pace (Harris, 2017). The benefits of BL to classroom teachers' were highlighted to include access to materials and tools from around the world that fit the student's interests and knowledge levels, availability of various exercises to cater to a wide range of learning styles for learners; independent pace lowers anxiety, boost fulfillment, and helps slow or fast learners retain knowledge, blended learning makes it possible for learners and teachers to communicate more effectively by using emails, message boards, conversation rooms; parents and learners can keep note of their school progress; flexible scheduling options are available with blended learning, and it gives the learner the flexible access to the materials anytime and from anywhere while providing personalized support and guidance (Giarla, 2016; Siew-Eng & Muuk, 2015; Stockwell et al., 2015).

Furthermore, research has indicated that learners exposed to blended instruction tend to outperform those exclusively in face-to-face or fully online classes (Mukhtaramkhon, 2022). Remarkable achievements have been recorded using blended learning as it increases networking opportunities for learners and teachers through collaborative tools (Stockwell et al., 2015). Through blended learning, teachers can optimize their teaching methods to assist every student in reaching their full potential. Studies have identified that blended learning can improve and enhance science learning in the classroom (Siew-Eng & Muuk, 2015; Susiyawati et al., 2021). BL is said to help learners' communication, critical thinking, problem-solving skills, innovation, collaboration, and creative thinking, which are vital skills in scientific inquiry (Wahyuni et al., 2019). Critical thinking allows learners to decide what is fact and trustworthy or done through observation, investigating, examining, exploring, synthesizing, and drawing conclusions, which are essential skills needed in the scientific process (Ardianti et al., 2020; Hasanah & Malik, 2020; Wahyuni et al., 2019).

Interactive multimedia (IM) is used to describe a new generation of software programs predominantly concerned with information delivery. The multimedia constituent is characterized by image, sound, text, video, and animation, which are arranged into a logical program. The interactive element allows the user to manipulate the environment, typically through a computer (Adeyele & Aladejana, 2018; Ogunseemi et al., 2016). Interactive multimedia have an audiovisual component that is created to actively involve the user's response (Mursid et al., 2019). Multimedia combines and incorporates text, sound, videos, graphics and animation in education (Rajendra & Sudana, 2018). Multimedia can deliver successful outcomes in the teaching-learning process. This approach allows static information to be transformed and transmitted because multimedia is dynamic. The dynamic nature of multimedia helps in integrating it into education by creating a new concept of learning that combines educational and entertainment approaches (Adeyele & Aladejana, 2018; Rajendra & Sudana, 2018).

Interactive multimedia have several benefits including assisting teachers in delivering their lesson plans. Interactive multimedia is also viewed as a means of communication that connects abstract ideas with the actual world. Using the IM also facilitates the process of collaboration, communication, delivery of lessons, and interaction between teachers and learners so that it is done properly and efficiently (Mursid et al., 2019). The benefit of interactive multimedia is the classroom includes to improve learners memory ability, encourage learner to actively participate in the class achieve more pieces of information at the same time (Oyeyemi et al., 2016). Interactive multimedia makes it easier for learners to master basic skills through training and practice. It helps solve problems through hands-on learning, grasps abstract concepts, provides better access for teachers and students in remote places, facilitates individual and collaborative learning, helps to manage classroom activities, and learning content (Malik & Agarwal, 2012). IM also simulate troubleshooting environments. IM has contributed immensely to teaching, by providing an advanced learning system, innovative learning environments, innovations in search of a breakthrough in creative learning, the combination of text, moving images, video, sound, or music into a mutually supportive unit to achieve learning objectives, the ability to motivate learners to achieve the intended learning outcomes, and training learners to be more independent in gaining knowledge (Rajendra & Sudana, 2018; Silaban & Tanjung, 2015).

The varying abilities could be defined as diversities in individual skills or competencies in a specific area or task. It is the concept that people have different abilities or talents and that these differences can appear in different fields such as academics, sports, music, or the arts (Montague & Van Garderen, 2003; Schack, 1993; Taylor, Matthew et al., 2011). In the classroom, for example, students may have different abilities in reading, writing, math, and other subjects. Some students can easily grasp the concepts and succeed in their studies, while others struggle with the same material. It is important to recognize that diversity of ability is a natural and normal part of human diversity and must be respected and embraced to ensure that all people have an equal opportunity for success.

Varying ability in the context of this study is referred to as an individual child with diverse capacities or capabilities. It could be children in mainstream schools who do not have any physical handicap or mental impairment, or special needs children with a mental disability, physical handicap, or psychological disability in special schools.

2.2 The interplay between educational tools and educational models

The relationship between educational tools and the education model is a dynamic and integral aspect of modern pedagogy. Educational tools frequently intersect with the education model, creating a holistic approach to teaching and learning. This dynamic is observed in numerous countries, including New Zealand, Ireland, and Sweden, where incorporating models is a common and essential practice (Brink et al., 2022). Education models serve a dual purpose within the educational landscape. They function as pedagogical tools, enhancing the effectiveness of teaching and learning processes. Simultaneously, these models become integral components of the teaching content itself, enriching the educational experience for students (Brink et al., 2022; Nia & de Vries, 2017).

For instance, New Zealand places significant emphasis on integrating models into the educational framework. Here, models are not only instructional tools but also essential components of the curriculum, demonstrating their critical role in fostering comprehensive technological literacy among students (Kellow, 2019). Ireland and Sweden similarly recognize the value of models as essential educational tools, particularly in the context of technology education. Models here are employed not only to facilitate learning but also to serve as a tool to provide a practical and tangible foundation for students to explore and engage with the teaching and learning processes actively (Darling-Hammond et al., 2020).

Shifting the focus to the integration of simulation games and interactive multimedia, it becomes evident that while these are tools, they often intersect harmoniously within the context of blended learning. As an educational model, blended learning capitalizes on integrating educational tools to create a richer learning experience. This integration of educational tools, such as simulation games and interactive multimedia, enhances the overall learning experience for students in blended environments. Therefore, this study's decision to examine these elements together is rooted in the practical reality that they are frequently intertwined in modern pedagogical practices. Moreover, the study acknowledges the practical implications of this integration. By investigating the collective impact of simulation games, interactive multimedia, and blended learning, this study aims to provide insights that educators across diverse educational settings can readily apply. This approach recognizes and addresses the real-world scenario where these elements often complement each other, resulting in a more enriching and practical learning experience for learners.

3 Methodology

3.1 Research design

The research employed a pretest-posttest control group quasi-experimental design to measure the impact of the three independent variables on the dependent variable, which is the achievement in Basic Science. The focus is to assess the impact of these innovative teaching approaches on pupils' science achievement, particularly in topics on living things and non-living things, body parts, animals and their habitats, and weather pattern, with varying levels of ability.

3.2 Development of teaching apps

A combination of lesson design, game development, and multimedia creation techniques was employed to build a thorough and exciting learning environment for the learners. The first stage in creating the teaching apps was reviewing existing literature and consulting with experts. Based on this, simulation games and interactive multimedia were developed. Other stages involved in the process include need analysis, design, development, implementation, and assessment.

3.2.1 Simulation games

The simulation game was designed and created to engage learners in interactive environments that encourage them to relate scientific principles to real-world situations that are familiar to them. The simulation game includes interactive features that allow learners to engage with the learning content and apply their knowledge; it gives immediate feedback and enables them to progress after completing a task.

3.2.2 Interactive multimedia

Interactive multimedia incorporates a collection of animations, videos, audio, and interactive simulations. The approach offers a fun and interactive learning environment to help learners better understand complex scientific concepts or phenomena. The learning environment allows learners to navigate the subject matter, permits both individualized and group interaction, provides quick feedback, and allows them to proceed to the next level of content when finished with a task.

3.2.3 Blended learning

Blended learning combines e-learning and in-person instruction, merging traditional teaching methods with e-learning. In this study, students were taught in the classroom using traditional methods using talk-chalk and printed materials and given access to e-learning apps. Teacher-directed and learner-directed approaches were employed.

3.3 Sample and sampling techniques

The study used a multistage sampling technique, where four states were randomly selected from six states in South-West Nigeria, and one regular and special school was selected from each state to make eight schools. Six experimental groups of pupils with varying abilities (three mainstream and three special schools) and two control groups (one mainstream and one special school) were used for the study.

3.4 Research instrument

The research instruments used for the study were the Simulation Games Wallets (SGW), Blended Learning Package (BLP), and Interactive Multimedia Platform (IMP). The SGW consists of five simulation games, blended learning combines traditional learning and e-learning, and IMP consists of five multimedia stages designed for teaching and learning basic science. Talk-chalk (TC) was used to instruct those in the control group. Talk-chalk involves the traditional method and printed materials. The Basic Science Achievement Test (BSAT) was used to measure the pretest and posttest effectiveness of the interventions.

3.5 Procedure of data collection

Pretests were conducted for the experimental groups and control groups before their exposure to the treatment SGW, BLP, and IMP to determine the entry performance of the learners using BSAT. After exposing the learners to the packages for a period of 12 weeks, the posttest was administered using BSAT to determine the performance after exposing participants to the treatment.

3.6 Ethical considerations

Permission was sought from the Local Government Education Authorities (LGEA) to make use of the schools in their jurisdictions for the experiment. Parents signed a consent form was provided to all participants; minor ascent form was all. Assumed names were used to replace participants' names in the experiment.

4 Results

Table 1 shows the demographic characteristics of the study participants. It presents a breakdown of the participants based on gender and age groups. In mainstream schools, there were a total of 24 male pupils, constituting 45.3% of the sample, and 29 female pupils, representing 54.7% of the sample. Similarly, in special schools, there were 21 male pupils, making up 39.6% of the total, and 32 female pupils, accounting for 60.4% of the total. The age distribution of the pupils is also outlined in the table. In mainstream schools, the age groups were as follows: ages 5–7, comprising 17 pupils (32.1%); ages 8–10, encompassing 29 pupils (54.7%); and ages 11 and above, consisting of 7 pupils (13.2%). In special schools, the age distribution was as follows: ages 5–7, with 12 pupils (22.6%); ages 8–10, including 23 pupils (43.7%); and ages 11 and above, with 18 pupils (34%). These findings suggest that there is a higher number of female pupils in both mainstream and special schools, and most of the pupils in both settings fall within the age group of 8–10 years old.

To determine the pretest scores of pupils with varying abilities (mainstream and special schools), the scores of the groups were subjected to descriptive statistics. The mean and standard deviation values of each of the groups were presented in Table 2.

Table 2 shows the descriptive analysis of the pretest score of pupils in mainstream and special schools for the experimental groups and the control groups. The result shows that there is no significant difference in the mean score of the groups before

Table 1 Demographic variables of the participants

	Type of school			
	Mainstream schools		Special schools	
	N	%	N	%
Gender				
Male	24	45.3	21	39.6
Female	29	54.7	32	60.4
Total	53	100%	53	100%
Age				
5–7	17	32.1	12	22.6
8–10	29	54.7	23	43.4
11 & above	07	13.2	18	34.0
Total	53	100%	53	100%

Table 2 Descriptive statistics of pupils' pretest scores of pupils with varying abilities (Mainstream & Special school)

Group	Pretest Mainstream school			Pretest Special school		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation
Simulation Games	15	10.07	2.086	11	9.27	3.259
Blended Learning	11	9.67	1.496	13	10.24	2.359
Interactive Multimedia	12	9.42	2.539	13	9.30	3.425
Talk-chalk	15	9.53	1.885	16	10.06	2.462

the treatment. This implies that the participants have the same entry level before exposure to treatment.

An additional attempt to establish the effect of the treatments (SG, BL, IM, TC) on the performance in basic science, Table 3 shows a group descriptive statistic of pretest - posttest scores of the treatment on basic science performance of pupils with varying abilities (mainstream and special schools).

Table 3 shows that the SG pretest mean scores of pupils in mainstream and special schools as 10.07 and 9.27, respectively, which signifies that there is no significant mean difference in the simulation games pretest score. While the SG posttest reveals a significant means difference in scores of pupils in mainstream and special schools as 31.4 and 29.31 respectively. Also, the result of the BL pretest mean scores of pupils in mainstream and special schools as 9.67 and 10.24 respectively, which indicated that there is no significant mean difference. Nevertheless, the BL posttest mean scores of pupils in mainstream and special schools show 28.44 and 30.53 respectively reveals a significant mean difference. Furthermore, pretest mean scores of pupils in mainstream and special schools as 9.42 and 8.69 respectively, which indicated that there is no significant difference in the interactive multimedia pretest score. Though the posttest mean scores of pupils in mainstream and special

Table 3 Pretest – Post-test group statistics of the treatments (SG, BL, IM, and TC) on pupils with varying ability (Mainstream and Special school)

Group		Mainstream School			Special School		
		N	Mean	Std. Deviation	N	Mean	Std. Deviation
Simulation Games	Pretest	15	10.07	2.086	11	9.27	3.259
	Post-test	15	26.17	5.937	11	22.46	7.102
Blended Learning	Pretest	11	9.67	1.496	13	10.24	2.359
	Post-test	11	28.44	3.609	13	30.53	3.523
Interactive Multimedia	Pretest	12	9.42	2.539	13	9.30	3.425
	Post-test	12	31.40	2.898	13	29.31	2.428
Talk-Chalk	Pretest	15	9.53	1.885	16	10.06	2.462
	Post-test	15	10.80	3.005	16	10.85	2.375

schools show 26.17 and 22.46 respectively indicating a significant mean difference. The mean pretest scores of the TC in the mainstream and special schools reveal no significant mean difference 9.53 and 10.06 respectively, and the post-test score of the control group also show no significant mean difference 10.8 and 10.85.

One key hypothesis is to test if the treatments (SG, BL, and IM) significantly enhance the achievement in Basic Science of pupils with varying abilities (mainstream and special schools). Tables 4, 5 and 6 shows the paired sample test of the pretest and post-test of the treatments on achievement in basic science of pupils with varying abilities.

Table 4 reveals the result of pupils in mainstream and special schools as $t=23.899$, $p=0.00$ and $t=7.178$, $p=0.00$ respectively. A null hypothesis is therefore rejected. This implies that there is a significant effect of simulation games in enhancing achievement in Basic Science of pupils.

Table 5 compared the impact of blended learning in improving the achievement in Basic Science of pupils with varying abilities. The table presents the results of pupils in mainstream school as $t=15.802$ and $p=0.00$ while special school pupils

Table 4 Paired sample test of the pretest-posttest simulation game

	Mean	Std. Dev	t	df	Sig.
Pair 1 Pretest Simulation Game Regular – Post-test Simulation Game Mainstream pupils	21.333	3.457	23.899	14	0.000
Pair 2 Pretest Simulation Game Special pupils – Post-test Simulation Game Special pupils	13.769	3.723	7.178	10	0.000

Table 5 Paired sample test pretest-posttest blended learning

	Mean	Std. Dev	t	df	Sig.
Pair 1 Pretest Blended Learning Mainstream – Post-test Blended Learning Mainstream pupils	18.182	3.816	5.802	10	0.000
Pair 2 Pretest Blended Learning Special pupils – Post-test Blended Learning Special pupils	20.769	4.186	17.888	12	0.00

Table 6 Paired samples test of the pretest and the posttest score of interactive multimedia

	Mean	Std. Dev	t	df	Sig.
Pair 1 Pretest Interactive Multimedia Mainstream – Post-test Interactive Multimedia Mainstream pupils	16.75	4.224	13.73	11	0.000
Pair 2 Pretest Interactive Multimedia Special pupils – Post-test Interactive Multimedia Special pupils	13.769	6.858	7.24	12	0.000

show 17.888; p = 0.00, which shows a significant impact of blended learning in enriching the achievement in Basic Science of pupils with varying abilities. Therefore, the null hypothesis is rejected and conclude that blended learning significantly improves pupils' achievement in basic science regardless of their ability.

As shown in Table 6 above, the result of pupils in mainstream school reveal t = 13.737, p = 0.000 while pupils in special school t = 7.24, p = 0.000. This suggests that there is a significant effect of interactive multimedia in improving achievement in Basic Science of pupils with varying abilities.

The main hypothesis is to compare the effectiveness of the treatments (SG, BL, and IM) on basic science achievement of pupils with varying abilities. In addressing this, the hypothesis was tested using Two-way between groups ANOVA.

Table 7 shows the factors that are considered in this hypothesis. The varying abilities are mainstream or special school while the treatments are IM, SG, BL, and TC. These factors were considered in the subsequent tables.

The result of Table 8 showed the mean scores, standard deviation, and number of each subgroup. The mean scores indicated the impact of the treatment (IM, SG, BL & TC) used as the intervention based on the pupils varying abilities (mainstream and special schools). Interactive multimedia shows the highest average mean as 30.43 while simulation game and blended learning reveal 24.24 and 29.75 respectively. The control group present a mean score of 10.82, which is very small compared to the harmonic mean score of 26.13. The table also reveals that interactive multimedia is the most effective of all the treatments with pupils in mainstream schools, while blended learning is more effective in the case of pupils in special schools. On the other hand, simulation games are the least effective with the mainstream and special schools.

Table 9 shows the comparative effectiveness of varying abilities (mainstream and special schools) and the treatment on the achievement of pupils in Basic Science. The table presents that varying abilities does not significantly affect achievement in basic science (F = 1.259, p = 0.265). The results also show that the treatment (SG, BL, and IM) significantly affects basic science achievement of pupils (F = 129.239, p = 0.00). This suggests that SG, BL, and IM substantially contribute to basic science achievement of pupils with varying abilities. Furthermore, the result reveals that there is no significant interactive effect of the treatment and varying ability (F = 2.254; p = 0.087) on the achievement of pupils.

To ascertain which of the treatments (SG, BL, and IM) contribute to the achievement of the pupils in basic science, a post-hoc multiple comparison analysis of the

Table 7 Between-subjects factors varying ability/treatments

		Value label	N
Varying abilities	1	Mainstream School	53
	2	Special School	53
Treatments	1	Interactive Multimedia (IM)	26
	2	Simulation Game (SG)	24
	3	Blended Learning (BL)	25
	4	Talk-Chalk (TC)	31

Table 8 Descriptive statistics dependent variable: Post-test

Varying Ability	Treatment	Mean	Std. Deviation	N
Mainstream School	Interactive Multimedia	31.40	2.898	15
	Simulation Games	26.17	5.937	12
	Blended Learning	28.44	3.609	9
	Talk-Chalk	10.80	3.005	15
	Total	23.59	9.377	51
Special School	Interactive Multimedia	29.31	2.428	13
	Simulation Games	22.46	7.102	13
	Blended Learning	30.53	3.523	15
	Talk-Chalk	10.85	2.375	13
	Total	23.56	8.895	54
Total	Interactive Multimedia	30.43	2.847	28
	Simulation Games	24.24	6.704	25
	Blended Learning	29.75	3.627	24
	Talk-Chalk	10.82	2.681	28
	Total	23.57	9.088	105

Table 9 Two-way ANOVA result of the effect of varying ability on the treatment

	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6936.400[a]	7	990.914	58.137	0.000	0.808
Intercept	57715.847	1	57715.847	3386.190	0.0000	0.972
Varying Ability	21.454	1	21.454	1.259	0.265	0.013
Treatment	6608.411	3	2202.804	129.239	0.000	0.800
Varying Ability* Treatment	115.262	3	38.421	2.254	0.087	0.065
Error	1653.315	97	17.044			
Total	66929.000	105				
Corrected Total	8589.714	104				

interaction of the treatment was carried out using the Significant Difference (LSD) formula. The results as shown in Table 10.

Table 10 presents multiple comparison of pupils' achievement score, it was clear that the achievement of pupils in simulation game was significantly differs from that of interactive multimedia and blended learning. However, the pupils using interactive multimedia and blended learning achievement in Basic Science are the same. In addition, there is a significant difference between the achievement of pupils that were taught with IM, SG and BL and control groups that were taught with talk-chalk method.

Table 10 Multiple comparison analysis of interaction of the teaching strategies

(I) Method of Learning/Teaching	(J) Method of Learning/Teaching	Mean Difference (I-J)	Std. Error	Sig.
Interactive Multimedia	Simulation Game	6.19*	1.136	0.000
	Blended Learning	0.68	1.148	0.935
	Talk-Chalk	19.61*	1.103	0.000
Simulation Game	Interactive Multimedia	-6.19*	1.136	0.000
	Blended Learning	-5.51*	1.180	0.000
	Talk-Chalk	13.42*	1.136	0.000
Blended Learning	Interactive Multimedia	– 0.68	1.148	0.935
	Simulation Game	5.51*	1.180	0.000
	Talk-Chalk	18.93*	1.148	0.000

5 Discussion

The findings of this study reveal that simulation games are effective in instructing Basic Science among the pupils in mainstream and special schools. This also collaborates the views of Sowunmi and Aladejana (2016), National Research Council (2011) and Wong et al. (2022) that learners exposed to simulation games showed significant levels of growth in scientific education. Also, Lean et al. (2021), Pooja (2011) and Stoma et al. (2020) contented that providing pupils with simulation games can strengthen their engagement, provide them with problem-solving skills, improve and equip their social development, academic abilities, learner-centered learning, ingenuity, imaginative thinking, emotional objectives, a sense of completion and knowledge integration. However, the study revealed a significant difference in the posttest score of mainstream and special pupils who use simulation games. This could be accounted for by other essential factors that are not considered in this study. (Reed et al., 2012) attest to the fact that specific provisions should be put in place to promote success when comparing children in a mainstream with their special needs colleagues.

Also, the result of this revealed the effectiveness of the blended learning instructional strategy in enhancing pupils with varying abilities performance in Basic Science. This finding provides evidence of the results of the work of Aladejana, 2008); Giarla (2016), Siew-Eng and Muuk (2015), Stockwell et al. (2015), and Poon (2013) that blended learning provides opportunities for both teachers and learners to be active in the teaching and learning process, provide timely feedback, and respect different learning styles and talents. It promotes the development of communities of practice to give teachers access to collaborative planning and development of lesson plans and assessments, to offer additional educational support to teachers who are unwilling or unable to work together with others, allow teachers and learners to experience and explore the online learning environment by themselves and provide administrative support, by allocating classrooms equipped with tools that better integrate the two teaching methods. Correspondingly, there is no significant difference in the average mean scores of pupils in a mainstream school and those in the special school, with this one cannot say that a group performs better than the other. This result collaborates with Waddington and Reed (2017) that mainstream children have no superior academic accomplishment than children in specialist provision. However, the mean score of pupils in special schools is still greater than those in mainstream schools.

The result obtained in this study also shows that interactive multimedia is effective in enhancing Basic Science achievement regardless of pupils' varying ability. The pupils, whether in the mainstream or special school performance in basic science with the IM is significant. Based on the difference in the pupils' average mean scores, pupils in mainstream performed better than their counterparts in special schools. However, this finding provides evidence of the result of Adeyele and Aladejana (2019), Mursid et al. (2019), Rajendra and Sudana (2018), Shahzad et al. (2021), and Siregar and Sudrajat (2018) that interactive multimedia improve performance, engage learners intensely, increases the effective level of learning and allows learner participation in the learning activities. Rajendra and Sudana (2018), and Siregar and Sudrajat (2018) argues that with the use of interactive multimedia in the classroom, teachers may better explain scientific concepts to their learners.

The result obtained in this study further revealed the two-way interaction of school type and teaching strategies, it was found that they had no significant effect on pupils' achievement in Basic Science. Regardless of the pupils' varying abilities, they all achieve academic success when exposed to the same treatment. The result also supports the previous findings of Poon (2013) and Waddington and Reed (2017) learners with special needs have performed commensurately with their contemporaries in mainstream schools. Although the varying abilities also does not have a significant effect on the pupils' achievement, the teaching strategy does. This could be accounted for by the instructional package and other factors such as severity of needs, mental age of the learner, and others that are relative to specialist provisions.

Furthermore, comparison results of the effectiveness of the treatment shows that there is no difference in the achievement of varying ability pupils exposed to interactive multimedia and blended learning. This implies that where interactive multimedia is not readily available, blended learning could be used and viz. versa. Although simulation games are equally effective, it shows a significant difference from the other interventions, which could be because of other moderating effects that are not considered in the study.

6 Limitations

The study has some limitations that need to be acknowledged. Firstly, the study primarily focused on short-term outcomes through posttest results, offering a snapshot of immediate improvements. To gain a deeper insight into the long-term effects and sustainability of these observed enhancements, further investigation over an extended timeframe is warranted. Secondly, the study did not account for variations in the availability of resources, including technology and educational materials, which could impact the effectiveness of the teaching strategies. Future research should take into consideration the potential disparities in resources across educational settings. Lastly, moderating factors that were not accounted for in the study, such as age, gender, parental involvement, socioeconomic status, and school policies, may have influenced pupil performance. Future studies should consider these variables to provide a more comprehensive analysis of the factors at play in the educational process. Recognizing these limitations, it is essential for future research to address these constraints and continue exploring the dynamic landscape of teaching strategies and their impact on diverse learners. This will contribute to a more robust and nuanced understanding of effective educational practices in varying contexts.

Additionally, this study paves the way for future research endeavors to delve deeper into the nuances of these teaching strategies and their applications across various educational contexts, and potential gender-related and age-related nuances in the educational context. As technology and pedagogy continue to evolve, ongoing exploration and innovation in instructional methods will be essential to provide equitable and effective learning experiences for all students.

7 Conclusion and recommendation

In conclusion, this study offers evidence that simulation games, blended learning, and interactive multimedia teaching strategies can significantly enhance the academic achievements of learners with varying abilities in basic science. These findings underscore the effectiveness of these strategies and provide valuable guidance for educators and policymakers seeking to optimize learning outcomes. Based on the outcomes of this study, the following recommendations and insights emerge: Among the investigated teaching interventions, interactive multimedia emerged as the most versatile strategy, particularly for pupils in mainstream schools. Its effectiveness in engaging learners and facilitating academic success is undeniable. Therefore, this study strongly recommends further exploration and expansion of interactive multimedia within mainstream educational settings. This can serve as a cornerstone for maximizing learning outcomes in various subjects and grade levels. Also, for pupils with special needs, the blended learning approach exhibited commendable effectiveness in enhancing their performance in basic science. This study suggests that blended learning offers tailored support that aligns with the unique requirements of learners with special needs. As such, future research and implementation efforts should focus on refining and adapting blended learning programs to cater to this diverse group of learners. Furthermore, while simulation games demonstrated their effectiveness, they were less potent than other teaching strategies. However, this should not overshadow their value. Simulation games can serve as valuable supplementary tools, particularly when interactive multimedia and blended learning resources are not readily available. They provide an engaging and immersive learning experience that can complement other teaching approaches effectively.

In summary, these findings underscore the importance of tailoring teaching strategies to cater to the diverse needs of learners. Moreover, they emphasize the pivotal role of technology-enhanced learning in modern education. To sustain and build upon the positive impact of these strategies, educators and institutions must remain adaptable, open to innovation, and dedicated to fostering inclusive educational environments where every learner can thrive.

Funding Open access funding provided by University of Johannesburg. No funding was received for conducting this study.

Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest/Competing interests No conflict of interest was declared.

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