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The Effectiveness of Gravity Sketch Application in Virtual Reality for Isometric Drawing

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Abstract

In the Grafik Komunikasi Teknikal (GKT), isometric drawing themes are taught utilizing virtual reality (VR) and the Gravity Sketch application. Enhancing pupils' comprehension of spatial ideas and visualization abilities is the objective. Concerns over the caliber of TVET graduates are raised by the Education Development Plan 2013–2025, which emphasizes the drop in student performance following PMR. During the action research, lesson plans were created and used for isometric drawing themes using virtual reality as a teaching tool. 18 carefully chosen students participated in the action research, which included VR-based learning sessions led by a comprehensive curriculum. Pre-test, pass-test 1, and pass-test 2 data were gathered, and Friedman's tests showed notable gains. The findings demonstrate that using virtual reality (VR) in isometric sketching enhances student comprehension, satisfaction, and conceptual understanding. In summary, VR successfully enhances comprehension and visualization abilities, indicating broader acceptability in technical education and possible uses in other fields.

1. Introduction

Virtual Reality (VR) is a core element in the Industrial Revolution 4.0 (IR 4.0), resulting from the simulation of a 3D environment created through computer software (Kang & Kim, 2020). This environment can be controlled and interacted with by users. VR is a cutting-edge technology that simulates realistic scenarios about environments or products through computer simulations (Rasheed Ch & Khushnood, 2019). According to Onele (2021), VR technology has advanced significantly and revolutionized our interaction with the digital world. Various multimedia applications support VR's effective use across multiple fields. VR encompasses several key elements to create an immersive experience (Gibbs et al., 2022). These elements include Virtual Environment, Virtual Presence, Sensory Feedback, and Interactivity (Taylor, 1997). These elements work together to immerse users in a simulated reality, enabling them to interact and experience the virtual environment as if it were real. Sensory feedback in VR aims to provide a deeper, more realistic experience by utilizing various forms of sensory feedback, such as visual, auditory, and haptic feedback (Darzentas et al., 2015; Wang et al., 2023).

Gravity Sketch is one of the VR applications that allows users to create and design three-dimensional models and artworks in a virtual environment. Using VR devices, users can manipulate shapes and objects in three-dimensional space (Joundi et al., 2020). Gravity Sketch supports rapid prototyping and iterative design in product design and industrial engineering (Seybold & Mantwill, 2021). It also benefits architects, interior designers, and educators, particularly in subjects like geometry, astronomy, and geoscience. In education, subject Grafik Komukasi Teknikal (GKT), introduced in 2017, replaces the Engineering Drawing or Lukisan Kejuruteraan (LK) subject in national secondary schools. GKT requires high levels of imagination and visualization skills, closely related to engineering. The Standard Secondary School Curriculum aims to produce knowledgeable and skilled students in GKT, fostering creativity, innovation, and inventiveness. VR, equipped with sensory feedback elements, can enhance students' imagination and visualization skills, creating a new atmosphere in teaching and learning activities (Salleh et al., 2021). Combining the Gravity Sketch application with VR in the GKT subject helps students communicate effectively through graphics, stimulates visualization skills, and fosters interest in technological and engineering fields.

1.1 Problem Background

In the SPM exam, the assessment format for Chapter 1 of the Technical Graphic Communication (GKT) subject consists of two parts: Part A with a theoretical question worth 30 marks and Part B with a drawing skill question worth 70 marks. Studies have shown that many students struggle with questions that are not routine and have a low understanding and negative attitude towards GKT. (Rayung, Ambotang, & Batjo, 2023; Tee et al., 2023). High visualization skills are essential for academic excellence, and weak visualizing skills can lead to difficulties in understanding content (Nordin et al., 2010; Abdul Razak & Nordin, 2009). Consistent training is essential to enhancing these skills, and ignoring tasks can cause students to fall back. (Ismail, Wan Abdullah, & Mamat, 2020). Students require higher visualization skills for topics such as Isometric Drawing, where they must interpret 3D drawings. Many students lack knowledge in using these skills, which limits their ability to solve problems. (Kanapathy, 2016). Effective use of advanced teaching aids is required to enhance learning, but their use is still at a moderate level (Hamdan & Mohd Yasin, 2010; Johar, 2018). GKT teachers need more teaching help beyond textbooks to help students understand concepts thoroughly (Tee et al., 2023). The researchers, with 10 years of experience as GKT teachers, noted that students often struggle with Part B due to weak visualization skills, especially in interpreting orthographic projections. Although AutoCAD software is used in GKT classrooms, inadequate computer facilities in schools prevent effective teaching and learning. Continuous use and training in AutoCAD can improve students' skills and creativity, improving their visualization capabilities (Ismail, Wan Abdullah, & Mamat, 2020). Teaching modules and tools, including VR, can create an effective and interactive learning environment (Hasyimunfazlie, 2003). VR provides an exciting learning environment with a variety of media, facilitating experiential learning and connecting students with learning contexts (Said & Umar, 2007). Integrating VR into GKT can stimulate student visualization skills, especially in topics such as Isometric Drawing, offering new approaches to teaching and learning.

2.0 Literature Review

2.1 VR in Education

Piovesan et al. (2012) stated that various types of technology have been applied in the education system. Technological revolutions enable new approaches in teaching and learning processes. One such technology conducive to creating innovative educational tools is VR, which offers 3D computer environments and more effective interaction systems, thereby enhancing learning motivation. However, many educators are still unaware of VR's potential as a teaching tool to enhance students' experiences and learning processes (Ludlow, 2015). VR has significantly impacted education by introducing more interactive, dynamic, and innovative learning methods. According to Zainol Abidin, Norman, and Mohd Noor (2021), VR is currently used to present complex information in an engaging, accessible, and easy-to-learn manner, allowing students to interact with peers or objects in the VR environment to explore and develop their skills. VR tools in education bring a major transformation, providing realistic and practical experiences without leaving the classroom. In science education, VR enables students to explore microscopic organisms, different types of planets, or molecular structures in ways that are impossible in real life. Bryne (1996) stated that VR makes it easier to understand atomic structures in science education. In medical education, students can use VR to simulate surgical procedures or emergency medical situations, allowing them to hone practical skills without real-life risks. Dickey et al. (2016) conducted a study where urology faculty trainees used VR for surgical training, and most respondents showed positive interest. In math education, VR helps students understand complex concepts visually and interactively, such as manipulating 3D models or using geometry in real-life scenarios. Zainol Abidin, Norman, and Mohd Noor (2021) noted that VR allows students to experiment with different shapes in a virtual environment. Using VR headsets, students can deeply explore specially designed virtual environments, such as human anatomy structures or historical site simulations, without leaving the classroom. Mohamed Salleh et al. (2021) explained that VR headsets allow students to hear readings of intentions, prayers, and explanations of the Hajj timeline, contributing to more active and in-depth learning with positive impacts on understanding and knowledge application. With the continuous advancement of VR technology, education is moving toward a more dynamic and effective future. VR can also enhance collaborative learning, allowing students worldwide to work together in specially built virtual environments, leading to better idea exchange and cultural understanding. Yusof et al. (2017) stated that VR provides environments for visual and audio interactions, aiding knowledge construction and bringing significant changes to learning methods, making sessions more effective and achieving previously unattainable learning goals.

2.2 Constructivist Learning Theory in the Use of Virtual Reality (VR)

The characteristics of virtual reality (VR) are closely linked to three aspects of educational theory: constructivism, social learning, and practical learning (Bricken, 1991). The use of VR brings significant changes in learning methods, aligning with the constructivist learning theory, which promotes active learning by encouraging students to build new knowledge based on their existing knowledge. VR provides an environment for active and interactive learning. Students do not just receive information passively; they can interact with the virtual environment, create objects, and organize their knowledge through experiences gained while using VR. Student-centered learning becomes more effective with VR as students can explore virtual worlds, make decisions, and create their own knowledge. Abdullah et al. (2013) stated that encouraging effort and responsibility in learning enables students to become knowledge builders about issues they encounter. Students can plan, create, and test ideas in the virtual world without restrictions, fostering creativity and problem-solving skills essential in constructivist learning. VR also enhances collaboration among users. Mahmud (2011) found that students can communicate with peers, share thoughts, and work on projects together in the virtual world, strengthening the interactive and social aspects of learning. This aligns with constructivist principles that emphasize the importance of social interaction in knowledge construction. Additionally, VR allows contextual learning by immersing students in relevant situations or environments. By integrating constructivist learning principles into VR, we provide meaningful, dynamic learning experiences suited to students' needs in the digital age. VR's contributions are evident in improving educational processes and techniques while supporting Constructivist Theory (Romli, Abu Bakar, & Shiratuddin, 2001). The conceptual framework in this study uses the Experiential Learning Model introduced by David Kolb (1984). According to Abdulwahed & Nagy (2009), the Experiential Learning Model by David Kolb (1984) is suitable for this study, encompassing four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. This framework involves sensory feedback in VR, constructivist learning theory, and active teaching techniques. It emphasizes direct experience, engaging multiple senses, and active reflection, allowing students to build deeper knowledge through practical experiences and interactive teaching methods.

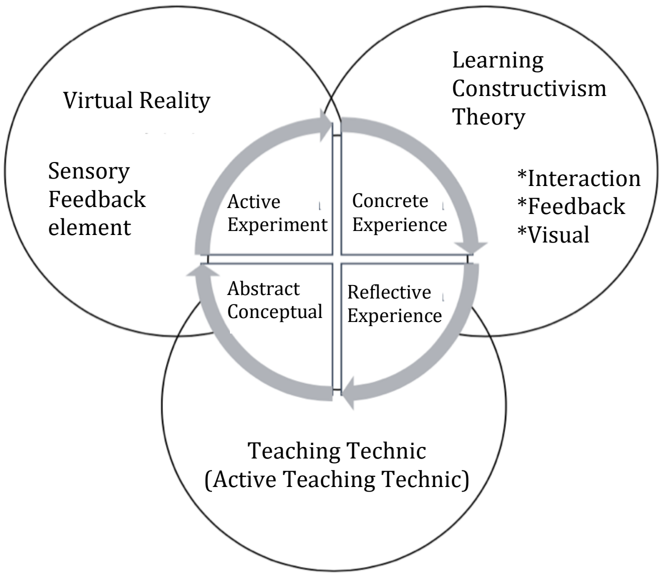

Fig. 1 *The Conceptual Framework of the Study is adapted from the Experiential Learning Model by David A. Kolb (1984) and involves the combination of the variables Sensory Feedback, Constructivist Learning Theory, and Teaching Techniques.*

3.0 Objective

The objectives of the study are:

- Develop a daily lesson plan (RPH) for the topic of isometric drawing based on the use of VR as a Teaching Aid.
- Identify the effects of implementing the Gravity Sketch application in VR as a suitable teaching aid in the Grafik Komunikasi Teknikal (GKT) subject.

4.0 Methodology

The importance of using the Gravity Sketch program through virtual reality for the topic of isometric drawing for the Technical Graphics Communication course was examined in this qualitative study, which was designed as action research. Action research, according to McNiff (1988), raises student accomplishment by making teachers more conscious of their methods, critical of them, and willing to change them. Lebar (2011) asserts that several approaches are employed based on the information and data needed to carry out action research. Using virtual reality as a teaching tool, the researcher created a Daily Lesson Plan (RPH) for isometric drawing as part of this action research project. Pre-test and post-test tools were then utilized to collect study data. This study, which involved 18 Form 4 students enrolled in the Grafik Komunikasi Teknikal (GKT) course, employed a purposive sample technique. According to Nyimbili and Nyimbili (2024), a sample is the number of participants who actively participated in a study and represented the wider group from which they were chosen. A sample is also a smaller group of people who share characteristics with the study's main population. Purposive sampling was used in this study since it is straightforward and easy to apply, and it has also served as a reference for this investigation (Campbell et al., 2020).

5.0 Daily Lesson Plan (Rancangan Pengajaran Harian – RPH)

The development of this Daily Lesson Plan (RPH) is part of the process for the researcher to test the effectiveness of using VR in teaching the topic of Isometric Drawing, to achieve one of the objectives of the action research. According to Abdul Razak et al. (2021), systematically planning learning activities in the Daily Lesson Plan (RPH) can help improve the effectiveness of the teaching and learning process. For this action research, VR will be used during the teaching and learning sessions for the topic of isometric drawing as a teaching aid. The use of VR, facilitated by the teacher along with the students, will be integrated into the learning activities. The detailed use of VR throughout the teaching process for the entire isometric drawing topic will be tailored to the teaching activities to achieve the learning outcomes specified in the Daily Lesson Plan (RPH). After the teaching session, if the researcher is not satisfied with the teaching results, the teaching steps can be repeated, known as the second cycle. The first cycle of the Daily Lesson Plan (RPH) for isometric drawing using VR as a teaching aid is designed to cover the entire Content Standards and Learning Standards. Before proceeding with the teaching process, the VR set is introduced, and the teacher allows the students to try it first to ensure comfort and enjoyment while using VR. Once the students are comfortable and understand how to operate the VR, the teacher can begin teaching isometric drawing using VR as a teaching aid. After the teaching session covering the entire topic, Post-Test 1 is given to the students. Post-Test 2 is administered after repeating the teaching with VR using a modified RPH to achieve the learning objectives.

5.1 Analysis of the Isometric Drawing RPH Using VR as a Teaching Aid

To ensure the RPH can be used effectively, an evaluation is conducted to measure the suitability of the content and the usability of the Daily Lesson Plan (RPH) for Isometric Drawing using VR as a teaching aid. This analysis is based on the content evaluation process of the RPH, conducted by experts through face-to-face meetings and online evaluation forms. Six experts, including experienced teachers in positions such as Head of Department, Area Assessors, and lecturers in related fields, have been appointed to carry out the evaluation.

Table 1 Isometric drawing RPH analysis with the use of VR as BBM

	Statement	Mean	Standard Deviation	Level
1	Writing Objectives or Learning Outcomes	4.67	.516	High
2	Writing the Selection and Organization of Lesson Content	4.33	.816	High
3	Writing Teaching Aids and Materials.	4.67	.516	High
4	Writing Teaching and Learning Strategies	4.50	.837	High
5	Writing Incorporating Noble Values in the Lesson Plan	4.00	1.095	High
6	Writing Incorporating Thinking Skills in the Lesson Plan	3.83	.753	High

Overall, the average mean value is 4.33, and the standard deviation is 0.756 for the analysis of the Isometric Drawing RPH using VR as a teaching aid. The standard deviation represents the variation between the sample values and the mean. Although the mean value is high, a low standard deviation indicates that the respondents tend to agree with the statement.

Table 2 *Expert Comments and Recommendations*

Panel	Well-Designed/ Developed Daily Lesson Plan (RPH)	Objectives are Written Well, Precisely, and Clearly	Learning Outcomes Detailed According to Learning Objectives	Teaching Aids that Align and Support Student Understanding	Increase Activities Using VR to Enhance Teaching Aids Functionality	Interspersing Drawing Activities and VR for Better Understanding
Panel 1	✓	✓		✓	✓	✓
Panel 2	✓	✓	✓	✓	✓	
Panel 3	✓	✓		✓		✓
Panel 4	✓	✓	✓	✓		✓
Panel 5	✓	✓	✓	✓	✓	
Panel 6	✓	✓	✓	✓	✓	✓

As per table 2 above, all six experts agreed that the Daily Lesson Plan (RPH) is well-structured and suitable for teaching Isometric Drawing using VR, with clear and precise learning objectives. They noted that VR effectively supports learning by providing modern technology exposure, enhancing understanding, and fostering creativity and critical thinking. Additionally, four experts recommended increasing VR-based activities and alternating them with drawing exercises to improve comprehension. They emphasized that incorporating diverse activities aligns with constructivist learning theory, enhancing student engagement and deeper understanding.

6.1 Analysis of Pre-Test and Post-Test

For the second objective research on the effectiveness of Gravity Sketch in VR as a suitable teaching aid in the Technical Graphics Communication subject, an analysis was conducted on 13 students who scored less than 10 marks in the pre-test.

Table 3 *Results of Pre-Test, Post-Test 1, and Post-Test 2 by Grade*

Grade / Marks	N	Pre-Test (%)	N	Post-Test 1 (%)	N	Post-Test 2 (%)
A+ (90 – 100)	0	0	0	0	1	7.7
A (80 – 89)	0	0	1	7.7	1	7.7
A- (70 – 79)	0	0	1	7.7	5	38.5
B+ (65 – 69)	0	0	1	7.7	3	23.1
B (60 – 64)	2	15.4	2	15.4	1	7.7
C+ (55 – 59)	1	7.7	3	23.1	0	0
C (50 – 54)	1	7.7	2	15.4	1	7.7
D (45 – 49)	0	0	1	1	1	7.7
E (40 – 44)	2	15.4	0	0	0	0
G (0 – 39)	7	53.8	2	15.4	0	0
Total	13	100	13	100	13	100

The analysis of pre-test, post-test 1, and post-test 2 results in Table 3 shows that using VR in teaching the Isometric Drawing topic in the Grafik Komunikasi Teknikal (GKT) subject improved student achievement. The pass rate increased from 46.2% in the pre-test to 84.6% in post-test 1 and 100% in post-test 2. Additionally, the percentage of students achieving grade A rose from 0% in the pre-test to 23.1% in post-test 1 and 53.9% in post-test 2. These findings clearly indicate that using VR as a teaching aid had a positive impact on student performance in Isometric Drawing. In this study, the Friedman Test was used to identify differences in mean achievement between the pre-test, post-test 1, and post-test 2, where data was measured on the same individuals at three different times. MacFarland & Yates (2016) explain that the Friedman Test is used when you have k related samples and the assumption of normality is not met. It is a non-parametric method equivalent to repeated measures ANOVA. The Friedman Test is a non-parametric test used to detect differences in treatments across multiple test trials. It serves as an alternative to repeated measures ANOVA when data do not meet the normality assumption.

Table 4 *The Friedman Test Shows Differences in Mean Achievement Between the Pre-Test, Post-Test 1, and Post-Test 2, as well as Significant Values*

Type of Test	N	*Mean Rank*	*p*
Pre-Test	13	1.08	.000
Post-Test 1	13	1.92	
Post-Test 2	13	3.00	

P < 0.05

The Friedman Test results at table 4 show a p-value of .000, indicating a significant difference in performance between the treatments ($p < .001$). In summary, the p-value of .000 in the Friedman Test provides strong evidence of a significant difference among the groups being compared. Therefore, follow-up (post hoc) tests will be conducted to identify which specific groups differ significantly from each other (Field, 2009).

Table 5 *The Wilcoxon post hoc test shows the analysis of differences in mean achievement and significant values*

Post Hoc Test	Type of Test	N	*Mean*	*p*
Pre-Test and Post-Test 1				
	Pre-Test	13	2.46	.003
	Post-Test 1	13	4.92	
Pre-Test and Post-Test 2				
	Pre-Test	13	2.46	.001
	Post-Test 2	13	7.15	
Post-Test 1 and Post-Test 2				
	Post-Test 1	13	4.92	.001
	Post-Test 2	13	7.15	

P < 0.05

For the pos hoc test at table 5 shows The Wilcoxon tests conducted between the Pre-Test and Post-Test 1 showed a significant p-value of .003, indicating a notable improvement in scores after implementing VR in the teaching of isometric drawing. The Wilcoxon test between the Pre-Test and Post-Test 2 showed a significant p-value of .001, demonstrating a larger and more sustained effect of VR on student performance by Post-Test 2. Similarly, the test between Post-Test 1 and Post-Test 2 revealed a significant p-value of .001, indicating a continued positive effect of VR. Overall, the significant p-values ($p < 0.05$) across all tests confirm that VR significantly impacted student performance in isometric drawing over the testing periods.

7.0 Discussion

The study conducted with six experts found that the Isometric Drawing Lesson Plan (RPH) using Virtual Reality (VR) as a Teaching Aid (BBM) met its objectives. It successfully developed a daily lesson plan for teaching isometric drawing with VR and assessed its usability during lessons. The research involved 18 students, using VR with the Gravity Sketch app for isometric drawing. Pre-tests, Post-test 1, and Post-test 2 were analyzed statistically to evaluate the effectiveness of VR. The results, detailed in Chapter 5, addressed the research questions effectively.

7.1 Development of Isometric Drawing Lesson Plans Using VR as a Teaching Aid

The overall analysis of the development of the Isometric Drawing Lesson Plan (RPH) with Virtual Reality (VR) as a Teaching Aid (BBM) reveals a high average mean across all writing sections. This indicates expert consensus that the RPH is well-crafted and applicable for teaching isometric drawing using VR. According to Zakaria & Norul'azmi (2023), effective teaching and learning rely on well-organized daily lesson plans. A well-structured RPH helps teachers plan and execute lessons more effectively. Experts also agreed that the writing of learning objectives in the RPH was clear measurable, and aligned with students' prior knowledge and learning standards. Abdul Razak, Said & Mohd Fakhruddin (2021) emphasize that precise and specific objectives enhance students' understanding and motivation. Additionally, the logical arrangement of lesson content and the choice of VR as a teaching aid were highly rated. VR helps students grasp complex isometric concepts by providing an immersive 3D experience, which aligns with the constructivist approach to active, technology-enhanced learning (Makransky & Lilleholt, 2018; Azman et al., 2014). Furthermore, the RPH's strategies for teaching and learning were deemed effective, incorporating diverse methods to address different learning styles (Tomlinson, 2001). The integration of moral values in the lesson plan was also highlighted as beneficial for holistic student development (Hashim, 1998). Finally, the inclusion of Higher Order Thinking Skills (HOTS) in the RPH was noted to enhance cognitive abilities and prepare students for future challenges (Mohd Zeki et al., 2021).

7.2 Implementation of Gravity Sketch Application in VR as an Effective Teaching Aid in GKT Subjects

The use of the Gravity Sketch application with VR shows potential as an effective teaching aid for isometric drawing. Previous findings indicate that VR implementation has improved teaching and learning outcomes. Safar & Abdul Raman (2021) found that VR in visual arts education enhances student creativity and spatial understanding. Improvements were evident in Post-test 1 results after students used VR, and further gains were observed in Post-test 2 following additional VR sessions. This study, which involved three tests, aligns with the action research cycles described by Kemmis and McTaggart (1988). Similarly, Mohd Reza & Mahmud (2021) demonstrated that action research cycles lead to more effective teaching and improvements. The use of VR like Gravity Sketch helps identify and address issues gradually, adjusting teaching methods to meet student needs (Mohd Reza & Mahmud, 2021). Gravity Sketch allows students to draw and refine sketches directly in a virtual space, providing an immersive and effective learning experience. According to constructivist theory, this application not only creates a more interactive and dynamic teaching style but also offers holistic learning outcomes. By using Gravity Sketch, students engage actively with learning materials, aligning with the constructivist principle of combining new knowledge with existing understanding (Ahamad et al., 2022). The study demonstrates that using Gravity Sketch with VR positively impacts student achievement in isometric drawing.

7.3 Difference in Mean Scores Between Pre-tests and Post-tests

The difference in mean scores between pre-tests and post-tests helps assess the effectiveness of teaching interventions. Pre-tests evaluate students' initial knowledge and skills before implementing a program, while post-tests measure changes or improvements afterward. For instance, Chai & Ng (2020) used pre-tests and post-tests to assess the impact of teaching interventions on student achievement before and after using picture books, allowing researchers to evaluate improvements resulting from teaching aids. The study's results, detailed in the previous chapter, show significant differences between pre-test, Post-test 1, and Post-test 2 scores after using VR as a teaching aid for isometric drawing. This indicates that VR provides a broader sensory feedback experience, which indirectly affects student performance and overall experience. Mi Feng et al. (2016) found that multi-sensory cues in VR environments can influence user performance and experience. VR allows students to interact directly with a 3D environment, enhancing their understanding of spatial and dimensional concepts in isometric drawing. Piovesan et al. (2012) noted that VR offers immersive and interactive educational experiences, potentially impacting students' comprehension and performance. Ogbonna (2021) also highlighted VR's role in enhancing education by providing sensory experiences with abstract concepts like isometric drawing. Therefore, the significant differences in mean scores between pre-test, Post-test 1, and Post-test 2 suggest that VR improves understanding and performance in isometric drawing. This improvement is likely influenced by the sensory feedback from VR, including visual, auditory, and interactive experiences. The constructivist theory supports this, suggesting that VR enhances learning by allowing students to build knowledge through active interaction with their learning environment (Voon & Amran, 2021). Thus, VR effectively delivers clearer, more interactive visual information, deepening students' learning experiences and improving their ability to visualize and solve isometric drawing problems.

8.0 Conclusion

In conclusion, the utilization of virtual reality (VR) in conjunction with the Gravity Sketch application exhibits favorable efficacy and a notable enhancement in the accomplishment and generation of isometric drawings. Students' performance on post-tests is improved by VR, but it also changes how they engage with it more deeply. Pre-test, Post-test 1, and Post-test 2 data clearly demonstrate that students' proficiency in isometric drawing increased following VR instruction. This technology offers a deeper interactive experience with the isometric drawing medium in addition to improving the visual quality of drawings. It demonstrates how important sensory feedback—a fundamental component of virtual reality—is to improving the efficacy of instructional technology, especially when it comes to subjects that call for spatial perspective and visual comprehension. Additionally, constructivist learning theory backs up the notion that learning is an active process in which students engage with learning settings and materials to generate knowledge based on their own understanding. Through more realistic and limitless drawing attempts, virtual reality (VR) enables students to participate more actively in a more comprehensive learning experience and acquire isometric drawing fundamentals. Students can engage more directly with a 3D world due to the sensory feedback they receive when using virtual reality, which improves their ability to precisely and efficiently visualize isometric drawings.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

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