



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th February, 2026

Website: <https://econferencia.com>

METHODOLOGY OF USING VISUAL TOOLS IN TEACHING GEOMETRY TOPICS

Elmurodov Jamshid Asatillayevich
Oriental University

Axmadov Samandar Zoir o'g'li
a student at Oriental University

Abstract:

Amid declining international mathematics scores, this paper proposes a methodological framework for integrating visual tools into geometry education to enhance student comprehension and engagement. Geometry, with its inherently visual nature, provides a fertile ground for leveraging technology to foster critical cognitive skills. This extended abstract outlines a structured approach that utilizes a range of visual aids, from Dynamic Geometry Software (DGS) like GeoGebra to immersive technologies such as Augmented and Virtual Reality (AR/VR). The methodology is grounded in established pedagogical models, including TPACK and SAMR, to ensure a meaningful integration of technology. It details a six-stage lesson plan (motivation, exploration, conjecture, explanation/proof, practice, reflection) designed to address common student errors and promote deeper conceptual understanding. The framework also incorporates assessment strategies, including rubrics and e-portfolios, to measure the development of spatial reasoning and problem-solving competencies. This research aims to provide educators with a practical, evidence-based methodology to transform traditional geometry instruction into a dynamic, interactive, and effective learning experience.



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th February, 2026

Website: <https://econferencia.com>

Keywords: Geometry Education, Visual Tools, TPACK, Dynamic Geometry Software, Spatial Reasoning, Augmented Reality, Assessment Rubrics.

Geometry is a cornerstone of mathematics education, crucial for developing spatial reasoning, logical thinking, and problem-solving skills [1]. However, students often struggle with its abstract concepts, leading to misconceptions and poor performance. Recent international assessments highlight a concerning trend; for instance, the PISA 2022 results revealed an unprecedented drop in mathematics performance across OECD countries, declining by almost 15 score points since 2018 [2]. In Uzbekistan, only 19% of students achieved at least Level 2 proficiency in mathematics, far below the OECD average of 69% [3]. These statistics underscore the urgent need for more effective teaching methodologies. Visualisation is fundamental to geometric thinking, serving as a bridge between abstract concepts and concrete understanding [4]. Visual tools, especially digital ones, can make geometric properties and relationships tangible. They support spatial reasoning, the ability to mentally manipulate 2D and 3D objects [5]; facilitate the use of multiple representations (e.g., algebraic and graphical) to deepen comprehension [6]; and aid in proof visualisation by making logical steps more intuitive [7]. The integration of such tools is not merely about using technology, but about fundamentally redesigning the learning experience. This requires a robust methodological framework that guides teachers in selecting and implementing tools effectively.

Aim and Research Questions

The primary aim of this study is to develop and outline a comprehensive methodology for using visual tools to improve the teaching and learning of geometry. The research is guided by the following questions:



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th February, 2026

Website: <https://econferencia.com>

What is an effective pedagogical sequence for integrating various visual tools (DGS, 3D models, AR/VR) into geometry lessons?

How can this methodology help address and mitigate common student errors and misconceptions in geometry?

What assessment strategies can effectively measure the impact of visual tools on students' geometric understanding and spatial reasoning skills?

Methodology

This study proposes a qualitative, design-based research methodology focused on developing a practical teaching framework. The framework is built upon two key theoretical models. The TPACK (Technological Pedagogical Content Knowledge) model serves as the core, emphasizing the synthesis of a teacher's knowledge of technology, pedagogy, and content (geometry) to create effective, technology-enhanced learning experiences [8, 9]. The SAMR (Substitution, Augmentation, Modification, Redefinition) model is used to scaffold the integration, encouraging teachers to move beyond simple substitution (e.g., a digital worksheet) towards redefinition, where technology enables new, previously inconceivable tasks (e.g., exploring complex 3D structures in AR) [10].

The proposed lesson structure follows a six-stage constructivist approach:

1. Motivation: Introduce a real-world problem or a visually engaging puzzle to spark curiosity.
2. Exploration: Students use a selected visual tool (e.g., GeoGebra, a 3D printing application) to freely manipulate objects, observe patterns, and explore the problem space. The teacher acts as a facilitator, posing guiding questions [11].
3. Conjecture: Based on their exploration, students formulate hypotheses about geometric properties or relationships.



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th February, 2026

Website: <https://econferencia.com>

4. Explanation/Proof: Students use the visual tool to justify their conjectures. For instance, dragging a point in a DGS can demonstrate that a theorem holds for infinite cases, providing a powerful visual argument [7].

5. Practice: Students apply their new understanding to solve a set of related problems, using the tools for support.

6. Reflection: Students document their findings, often in an e-portfolio, explaining their process and reflecting on their learning.

A key focus is addressing common student errors, such as confusing the properties of different quadrilaterals or misinterpreting the tangent-chord theorem [12, 13]. Visual tools provide immediate, dynamic feedback that helps correct these misconceptions. For example, using GeoGebra, a student can manipulate a shape and see instantly when it ceases to be a rhombus, reinforcing its specific properties [14].

Visual Tool	Geometry Topic	Didactic Purpose	Assessment Evidence
Dynamic Geometry Software (GeoGebra)	Circle Theorems	Explore dynamic relationships (e.g., angle at the center) and form conjectures.	Completed interactive worksheet with student-formulated conjectures.
3D Printing	Volume of Solids of Revolution	Make abstract calculus concepts tangible and understand cross-sections.	Physical 3D model evaluated with a rubric for geometric accuracy [15].
Augmented Reality (AR) App	3D Coordinate System & Vectors	Visualize and manipulate geometric objects in a real-world physical space.	E-portfolio screenshot with a written explanation of a vector operation.
Interactive Simulation	Tessellations	Discover properties of regular polygons and tiling patterns through experimentation.	Short quiz on the rules governing which shapes tessellate.
Virtual Reality (VR)	Non-Euclidean Geometry	Provide an immersive experience of abstract spatial concepts that are difficult to visualize.	Observation of student interaction and problem-solving within the VR environment.



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th February, 2026

Website: <https://econferencia.com>

Assessment is multifaceted. Student understanding is evaluated through diagnostic quizzes, observation of their interaction with the tools, and project-based tasks. A key component is the use of rubrics to assess 3D models or design projects, focusing on criteria like geometric accuracy, creativity, and explanation of mathematical principles [15, 16]. E-portfolio evidence, such as annotated screenshots or screen recordings, provides insight into the student's thought process and ability to communicate mathematical ideas.

Expected Results

The implementation of this methodology is expected to yield significant improvements in student outcomes. We anticipate a measurable increase in students' spatial reasoning abilities, as measured by pre- and post-tests like the Purdue Spatial Visualization Test [5]. Studies have shown that interventions using 3D tools can increase spatial skills by up to 25% in experimental groups [5]. Furthermore, we expect enhanced conceptual understanding and a reduction in common misconceptions, as dynamic visualization helps students build more robust mental models [14]. Student engagement and motivation are also expected to rise, as interactive and immersive technologies like AR/VR transform learning into a more active and enjoyable process [17, 18]. Research indicates that such tools can significantly boost motivation and reduce learning anxiety [19].

Practical Implications

This framework offers educators a structured yet flexible guide for modernizing geometry instruction. It provides concrete strategies for integrating technology in a pedagogically sound manner, moving beyond ad-hoc use. For curriculum developers, it offers a model for designing 21st-century learning materials that align with international standards and leverage the power of digital tools. Teacher training programs can use this methodology to develop pre-service and in-service



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th February, 2026

Website: <https://econferencia.com>

teachers' TPACK competencies, addressing a common challenge where educators lack the training to implement technology effectively [9, 20]. Ultimately, this approach can contribute to improving national and international student performance in mathematics by fostering deeper, more resilient geometric knowledge.

Limitations

The successful implementation of this methodology is subject to several limitations. The primary challenge is the digital divide, including inequitable access to hardware (e.g., VR headsets, 3D printers) and high-speed internet, which can constrain the application of more advanced tools. Another significant barrier is the need for sustained, high-quality professional development for teachers to build the necessary TPACK skills [20]. Without adequate training and institutional support, teachers may struggle to move beyond basic substitution levels of technology use. Finally, the effectiveness of some tools, particularly AR/VR, can be affected by technical issues such as calibration errors or software glitches, which may disrupt the learning flow [21].

REFERENCES

1. Almubarak, M., Maat, S. M., & Mahmud, M. S. (2025). Evolving three decades of geometry learning strategies: A combination of bibliometric analysis and systematic literature review. *Eurasia Journal of Mathematics, Science and Technology Education*, 21*(6), em2654.
2. OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education**. OECD Publishing. <https://doi.org/10.1787/53f23881-en>
3. OECD. (2023). *PISA 2022 Results: Country Note - Uzbekistan**. OECD Publishing. Retrieved from <https://www.oecd.org/en/publications/pisa-2022->



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th February, 2026

Website: <https://econferencia.com>

[results-volume-i-and-ii-country-notes_ed6fbcc5-en/uzbekistan_2bb94bf1-en.html](https://doi.org/10.1080/13546783.2023.2225219)

4. Schoenherr, J., et al. (2024). Visual aids as cognitive tools for Bayesian reasoning. *Thinking & Reasoning*, 30*(3), 348-381. <https://doi.org/10.1080/13546783.2023.2225219>
5. Medina Herrera, L. M., et al. (2024). Enhancing spatial visualization in mathematics education through augmented and virtual reality. *Frontiers in Education*, 9*, 1229126. <https://doi.org/10.3389/educ.2024.1229126>
6. Zakaria, M. I., et al. (2024). The role of GeoGebra in enhancing secondary school students' understanding of geometry. *International Journal of Learning, Teaching and Educational Research*, 23*(1), 145-162.
7. Komatsu, K., & Jones, K. (2020). Capitalising on affordances of a dynamic geometry environment in proving activities. *Educational Studies in Mathematics*, 105*, 263–284. <https://doi.org/10.1007/s10649-020-09983-4>
8. Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A framework for teacher knowledge. *Teachers College Record*, 108*(6), 1017-1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
9. Marange, I. Y., et al. (2023). Teaching Euclidean geometry with GeoGebra: Perceptions for in-service mathematics teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, 19*(12), em2367. <https://doi.org/10.29333/ejmste/13861>
10. Puentedura, R. R. (2014). *SAMR and TPACK: Intro to Advanced Practice**. Hippasus. Retrieved from http://hippasus.com/rrpweblog/archives/2014/12/11/SAMRAndTPCK_IntroToAdvancedPractice.pdf



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th February, 2026

Website: <https://econferencia.com>

11. Bertrand, M. G., Sezer, H. B., & Namukasa, I. K. (2024). Culturally responsive mathematics teaching with augmented and virtual reality. **PMC Psychology*, 1*(1), 1-18. <https://doi.org/10.5964/pmc-psychol.11533>
12. Pule, G. K., et al. (2025). Errors and misconceptions in solving tangent-chord theorem problems: A case of Grade 11 learners. **Journal of Innovative Education*, 15*(Special Issue), 157-171.
13. Rabab'ah, Y. (2025). The most common conceptual errors in primary school geometry. **Educational Process: International Journal*, 14*(1), 89-105.
14. Karakus, D. (2022). The effectiveness of GeoGebra software in correcting and making sense of professional errors. **International Journal of Technology in Education and Science*, 6*(1), 1-18. <https://doi.org/10.46328/ijtes.309>
15. George, E., et al. (2017). Accuracy and reproducibility of 3D printed models. **Radiographics*, 37*(6), 1824-1842. <https://doi.org/10.1148/rg.2017170029>
16. Yo'ldashev, S. I. (2025). Chizma geometriya va kompyuter grafikasi fanlarini integratsiyalash asosida grafik tafakkurni shakllantirish metodikasi. **Science and Education*, 6*(1), 220-231.
17. Su, Y. S., & Cheng, H. R. (2022). The impact of using a virtual reality immersive learning mathematics geometry system on students' technology acceptance, learning motivation, and learning effectiveness. **Frontiers in Psychology*, 13*, 829219. <https://doi.org/10.3389/fpsyg.2022.829219>
18. Eryigit, C. D. (2025). The effect of augmented reality-supported geometry activities on the geometry skills and motivation of preschool students. **Education and Information Technologies**. <https://doi.org/10.1007/s10639-025-13631-4>
19. Sebsibe, A. S., et al. (2025). GeoGebra: A mediating artifact to minimize students' misconceptions in learning function concepts. **International Journal of Mathematical Education in Science and Technology**. <https://doi.org/10.1080/0020739X.2024.2445891>



Global Conference on Medical and Health Sciences

Hosted Online from Madrid, Spain

Date: 14th February, 2026

Website: <https://econferencia.com>

-
20. Kholid, M. N., et al. (2023). A systematic literature review on the implementation of the TPACK framework for teaching mathematics. *Cogent Education, 10*(2), 2269047. <https://doi.org/10.1080/2331186X.2023.2269047>
21. Chaurasia, A., et al. (2025). Mitigating cybersickness in video see-through augmented reality with geometry aware passthrough. *arXiv preprint arXiv:2502.11497*.