DESAIN *6E INSTRUCTIONAL MODEL* TERINTEGRASI *AUGMENTED REALITY* UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR GEOMETRI 3D DITINJAU DARI *GEOMETRY SELF-EFFICACY* SISWA SMP

DISERTASI

Diajukan untuk Memenuhi Sebagian dari Syarat Memperoleh
Gelar Doktor dalam Pendidikan Matematika

Oleh

Sudirman
1906964

PROGRAM STUDI PENDIDIKAN MATEMATIKA
FAKULTAS PENDIDIKAN MATEMATIKA DAN ILMU PENGETAHUAN ALAM
UNIVERSITAS PENDIDIKAN INDONESIA
2022

Desain 6E *Instructional Model* Terintegrasi *Augmented Reality* Untuk Meningkatkan Kemampuan Berpikir Geometri 3D Ditinjau dari *Geometry Self-Efficacy* Siswa SMP

Oleh
Sudirman

Dr. Universitas Pendidikan Indonesia, 2022
M.Pd. Universitas Negeri Semarang, 2013

Sebuah Disertasi yang diajukan untuk memenuhi salah satu syarat memperoleh gelar Doktor Pendidikan (Dr.) pada Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam

Universitas Pendidikan Indonesia
September 2022

LEMBAR PENGESAHAN

DESAIN *6E INSTRUCTIONAL MODEL* TERINTEGRASI *AUGMENTED REALITY* UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR GEOMETRI 3D DITINJAU DARI *GEOMETRY SELF-EFFICACY* SISWA SMP

Disetujui dan Disahkan oleh:

Prof. H. Yaya S. Kusumah, M.Sc.,P.hD
Promotor merangkap Ketua

Dr. Bambang Avip Priatna Martadiputra, M.Si
Ko-promotor merangkap Sekretaris

Prof. Turmudi, M.Ed., M.Sc., Ph.D
Anggota Penguji

Dr. H. Dadang Juandi, M.Si
Anggota Penguji

Prof. Dr. Hamzah Upu, M.Ed
Penguji Luar Universitas

Mengetahui,
Ketua Program Studi Pendidikan Matematika
Universitas Pendidikan Indonesia

Dr. H. Dadang Juandi, M.Si.
NIP. 196401171992021001

ABSTRAK

Sudirman. (2020). Desain *6E Instructional Model* Terintegrasi *Augmented Reality* untuk Meningkatkan Kemampuan Berpikir Geometri 3D Ditinjau dari *Geometry Self-efficacy* Siswa SMP

Pandemi COVID-19 telah mendorong penggunaan teknologi informasi dan komunikasi (TIK) dalam pembelajaran matematika secara lebih intensif. Namun, ketidaksiapan sekolah dan rendahnya pengetahuan serta kemampuan guru dalam pemanfaatan TIK, yang harus diintegrasikan dengan aspek didaktis, pedagogis, dan materi, mengakibatkan rendahnya prestasi belajar matematika siswa. Berdasarkan observasi awal ke beberapa sekolah menengah pertama di Kabupaten Indramayu mengindikasikan bahwa di masa pandemi COVID-19, siswa mengalami kesulitan dalam memahami materi geometri 3D, sehingga pembelajaran geometri 3D dipandang kurang efektif. Penelitian ini bertujuan untuk menghasilkan desain pembelajaran 6E-IM terintegrasi AR yang dapat meningkatkan kemampuan berpikir geometri 3D dengan memperhatikan *geometry self-efficacy* siswa. Penelitian ini menggunakan pendekatan *mixed-method* jenis *sequential exploratory*. Partisipan yang terlibat pada penelitian ini yaitu guru matematika dan siswa sekolah menengah pertama di salah satu SMP N di Kabupaten Indramayu. Data yang dikumpulkan dari tahapan kualitatif dianalisis menggunakan prosedur analisis model Miles dan Huberman, sedangkan data yang diperoleh dari pengujian lapangan dianalisis secara kuantitatif menggunakan statistik parametrik yaitu Anava dan Ankova. Temuan penelitian mengungkapkan bahwa 1) siswa mengalami kesulitan dalam merepresentasikan, mengidentifikasi struktur spasial, dan melakukan pengukuran luas permukaan dan volume geometri 3D; 2) teknologi AR dapat diintegrasikan pada bahan ajar geometri 3D dan pembelajaran 6E-IM; 3) terdapat perbedaan signifikan peningkatan KBG3D antara siswa yang belajar menggunakan 6E-IM terintgerasi AR, 6E-IM, dan pembelajaran konvensional; 4) terdapat pengaruh signifikan dari pembelajaran (6E-IM terintegrasi AR dan 6E-IM) terhadap peningkatan kemampuan berpikir geometri 3D dengan memperhatikan *geometry self-efficacy* siswa.

Kata Kunci: Kemampuan Berpikir Geometry 3D, *Geometry Self-Efficacy*, 6E Instructional Model, Augmented Reality

ABSTRACT

Sudirman. (2020). Design of 6E Instructional Model Integrated Augmented Reality to Improve Thinking Ability of 3D Geometry Viewed from Geometry Self-efficacy of Junior High School Students

The COVID-19 pandemic has encouraged more intensive use of information and communication technology (ICT) in mathematics learning. However, school unpreparedness and teachers' low knowledge and ability to use ICT, which must be integrated with didactic, pedagogical, and material aspects, result in low student achievement in mathematics. Based on initial observations of several junior high schools in Indramayu Regency, it was indicated that during the COVID-19 pandemic, students had difficulty in understanding 3D geometry material, so 3D geometry learning was seen as less effective. This study aims to produce an AR-integrated 6E-IM learning design that can improve 3D geometric thinking skills by paying attention to students' geometry self-efficacy. This research used a mixed-method approach with a sequential exploratory type. The participants in this study were mathematics teachers and junior high school students in one of the N SMPs in the Indramayu Regency. Data collected from the qualitative stage were analyzed using the Miles and Huberman model analysis procedure, while the data obtained from field testing was analyzed quantitatively using parametric statistics, namely Anava and Ancova. The findings of the study reveal that 1) at the initial observation, students have difficulty in representing, identifying spatial structures, and measuring the surface area and volume of 3D geometry; 2) AR technology can be integrated into 3D geometry teaching materials and 6E-IM learning; 3) there is a significant difference in the improvement of KBG3D between students who learn using AR integrated 6E-IM, 6E-IM, and conventional learning; 4) there is a significant effect of learning (6E-IM integrated AR and 6E-IM) on increasing the ability to think 3D geometry by paying attention to students' geometry self-efficacy.

Keywords: 3D Geometry Thinking Ability, Geometry Self-Efficacy, 6E Instructional Model, Augmented Reality

DAFTAR ISI

DAFTAR PUSTAKA

Akkaya, A., Tatar, E., Berrin, T., & Ka, Õ. (2011). Using dynamic software in teaching of the symmetry in analytic geometry : The case of GeoGebra. *Procedia - Social and Behavioral Sciences*, *15*, 2540–2544. https://doi.org/10.1016/j.sbspro.2011.04.141

Alshehri, M. A. (2016). The impact of using (5E's) instructional model on achievement of mathematics and retention of learning among Fifth Grade students. *IOSR Journal of Research & Method in Education*, *6*(2), 43–48. https://doi.org/10.9790/7388-06214348

Anderson, D. S., & Piazza, J. A. (1996). Changing beliefs: teaching and learning mathematics in constructivist preservice classrooms. *Action in Teacher Education*, *18*(2), 51–62. https://doi.org/10.1080/01626620.1996.10462833

Andy Field. (2009). Discoveries statistics using SPSS. In *Sage*. https://doi.org/10.1190/1.1439489

Antonioli, M., Blake, C., & Sparks, K. (2014). Augmented reality applications in education. *The Journal of Technology Studies*, 96–107. https://doi.org/10.4018/978-1-5225-2110-5.ch010

Arbain, N., & Shukor, N. A. (2015). The effects of GeoGebra on students achievement. *Procedia - Social and Behavioral Sciences*, *172*(2007), 208–214. https://doi.org/10.1016/j.sbspro.2015.01.356

Armah, R. B., Cofie, P. O., & Okpoti, C. A. (2018). Investigating the effect of van hiele phase-based instruction on pre-service teachers' geometric thinking. *International Journal of Research in Education and Science*, *4*(1), 314–330. https://doi.org/10.21890/ijres.383201

Armah, R. B., & Kissi, P. S. (2019). Use of the van hiele theory in investigating teaching strategies used by college of education geometry tutors. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(4). https://doi.org/10.29333/ejmste/103562

Arvanitaki, M., & Zaranis, N. (2020). The use of ICT in teaching geometry in primary school. *Education and Information Technologies*, *25*(6), 5003–5016. https://doi.org/10.1007/s10639-020-10210-7

Atasoy, E. (2019). Elementary mathematics teacher candidates' geometric thinking levels and their self-efficacy in geometry. *Acta Didactica Napocensia*, *12*(2), 161–170. https://doi.org/10.24193/adn.12.2.12

Auliya, R. N., & Munasiah, M. (2020). Augmented reality affects students' attitude and conceptual understanding in learning 3D geometry. *JPI (Jurnal Pendidikan Indonesia)*, *9*(2), 203. https://doi.org/10.23887/jpi-undiksha.v9i2.17480

Ayotola, A., & Adedeji, T. (2009). The relationship between mathematics self-efficacy and achievement in mathematics. *Procedia Social and Behavioral Sciences*, *1*(1), 953–957. https://doi.org/10.1016/j.sbspro.2009.01.169

Azuma, R. T. (1997a). A survey of augmented reality. *Presence: Teleoperators and Virtual Environments 6*, *6*(4), 355–385. https://doi.org/10.1561/1100000049

Azuma, R. T. (1997b). A Survey of Augmented Reality. *In Presence: Teleoperators*

and Virtual Environments 6, *4*, 355–385.

Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2014). Augmented reality trends in education: A systematic review of research and applications. *Educational Technology and Society*, *17*(4), 133–149.

Bada, S.O. (2015). Constructivism Learning Theory: A paradigm for Teaching and Learning. IOSR journal of Research & Method in Education, 5(6), 66-70

Bako, L., Mercère, G., & Lecoeuche, S. (2009). Identification of multivariable canonical state-space representations. *IFAC Proceedings Volumes*, *42*(10), 1638–1643. https://doi.org/10.3182/20090706-3-fr-2004.00272

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://doi.org/10.1007/978-3-319-75361-4

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*.

Battista, M. T. (1999). Fifth graders' enumeration of cubes in 3D arrays: Conceptual progress in an inquiry-based classroom. *Journal for Research in Mathematics Education*, *30*(4), 417–448. https://doi.org/10.2307/749708

Battista, M. T. (2004). Applying cognition-based assessment to elementary school students' development of understanding of area and volume measurement. *Mathematical Thinking and Learning*, *6*(2), 185–204. https://doi.org/10.1207/s15327833mtl0602_6

Battista, M. T., & Clements, D. H. (1996). Students' understanding of three-dimensional rectangular arrays of cubes. *Journal for Research in Mathematics Education*, *27*(3), 258–292. https://doi.org/10.2307/749365

Ben-Haim, D., Lappan, G., & Houang, R. . T. . (1985). Visualizing rectangular solids made of small cubes: Analyzing and effecting students' performance. *Educational Studies in Mathematics*, *16*(4), 389–409. https://doi.org/https://doi.org/10.1007/BF00417194

Block, J. (1982). Assimilation, accommodation, and the dynamics of personality development. *Child Development*, *53*(2), 281–295.

Boopathiraj, C., & Chellamani, K. (2013). Analysis of test items on difficulty level and discrimination index in the test for research in education. *International Journal of Social Science & Interdisciplinary Research*, *2*(2), 189–193.

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented Reality in education-cases, places and potentials. *Educational Media International*, *51*(1), 1–15. https://doi.org/10.1080/09523987.2014.889400

Brod, G., Werkle-Bergner, M., & Lee Shing, Y. (2013). The influence of prior knowledge on memory: A developmental cognitive neuroscience perspective. *Frontiers in Behavioral Neuroscience*, *7*(OCT), 1–13. https://doi.org/10.3389/fnbeh.2013.00139

Brousseau, G. (1997). *Theory of didactical situations in mathematics*. Dordrecht: Kluwer Academic Publishers.

Bybee, R. W. (2009). The BSCS 5E instructional model and 21st century skills. *Colorado Springs, CO: BSCS.*

Cahyono, A. N., Sukestiyarno, Y. L., Asikin, M., Miftahudin, Ahsan, M. G. K., & Ludwig, M. (2020). Learning mathematical modelling with augmented reality

mobile math trails program: How can it work? *Journal on Mathematics Education*, *11*(2), 181–192. https://doi.org/10.22342/jme.11.2.10729.181-192

Cai, S., Liu, E., Yang, Y., & Liang, J. C. (2019). Tablet-based AR technology: Impacts on students' conceptions and approaches to learning mathematics according to their self-efficacy. *British Journal of Educational Technology*, *50*(1), 248–263. https://doi.org/10.1111/bjet.12718

Cantürk-günhan, B., & Baser, N. (2007). Geometriye Yönelik Öz-Yeterlik Ölçeğinin Geliştirilmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *33*(33), 68–76.

Chairunnisa, C., Surya, E., & Sinaga, B. (2021). The difficulty analysis of students spatial ability based on Level Van Hiele in problem based learning. *Budapest International Research and Critics in Linguistics and Education*, *4*(1), 158–164. https://doi.org/10.33258/birle.v4i1.1569

Challenor, J., & Ma, M. (2019). A review of augmented reality applications for history education and heritage visualisation. *Multimodal Technologies and Interaction*, *3*(2). https://doi.org/10.3390/mti3020039

Cheema, J. R. (2017). Effect of math-specific self-efficacy on math literacy : Evidence from a Greek survey. *Research in Education*, 1–24. https://doi.org/10.1177/0034523717741914

Chen, C. J. (2010). Theoretical bases for using virtual reality in education. *Themes in Science and Technology Education*, 71–90.

Chen, Y. C. (2019). Effect of mobile augmented reality on learning performance, motivation, and math anxiety in a math course. *Journal of Educational Computing Research*, *57*(7), 1695–1722. https://doi.org/10.1177/0735633119854036

Cheng, K. K., Thacker, B. A., Cardenas, R. L., & Crouch, C. (2004). Using an online homework system enhances students' learning of physics concepts in an introductory physics course. *American Journal of Physics*, *72*(11), 1447–1453.

Chicchi Giglioli, I. A., Pallavicini, F., Pedroli, E., Serino, S., & Riva, G. (2015). Augmented reality: a brand new challenge for the assessment and treatment of psychological disorders. In *Computational and Mathematical Methods in Medicine*. https://doi.org/10.1155/2015/862942

Chiphambo, S. M., & Mtsi, N. (2021). Exploring grade 8 students' errors when learning about the surface area of prisms. *EURASIA Journal of Mathematics, Science and Technology Education*, *17*(8), em1985.

Christensen, L. B., Jhonson, R. B., & Turner, A. L. (2015). *Research Methods, Desaign, and Analysis* (Global Edi). Alabama: University of South Alabama.

Clements, D. H. (1998). Geometric and spatial thinking in young children. In *National Science Foundation, Arlington, VA*. https://doi.org/10.1166/sam.2014.1766

Clements, D. H., & Sarama, J. (2011). Early childhood teacher education: The case of geometry. *Journal of Mathematics Teacher Education*, *14*(2), 133–148. https://doi.org/10.1007/s10857-011-9173-0

Cobb, P., Yackel, E., & Wood, T. (1992). A constructivist alternative to the representational view of mind in mathematics education. *Journal for Research*

in Mathematics Education, *23*(1), 2. https://doi.org/10.2307/749161

Cohen, N., & Ben Gurion. (2003). Curved solids nets. *International Group for the Psychology of Mathematics Education*, (2), 229–236.

Coimbra, M. T., Cardoso, T., & Mateus, A. (2015). Augmented reality: an enhancer for higher education students in math's learning? *Procedia Computer Science*, *67*(Dsai), 332–339. https://doi.org/10.1016/j.procs.2015.09.277

Cooper, L. A. (1990). Mental representation of three-dimensional objects in visual problem solving and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*(6), 1097–1106. https://doi.org/10.1037/0278-7393.16.6.1097

Corrigan, P. W., Larson, J. E., & Rüsch, N. (2009). Self-stigma and the "why try" effect: impact on life goals and evidence-based practices. *World Psychiatry*, (8), 75–81.

Creswell, J., & Clark, V. L. . (2018). *Designing and Conducting Mixed Methods* (Third). California: SAGE Publications.

Crompton, H., Grant, M. R., Shraim, K. Y. H. (2018). *International Forum of Educational Technology & Society Technologies to Enhance and Extend Children's Understanding of Geometry: A Configurative Thematic Synthesis of the Literature Technologies to Enhance and Extend Children's Understanding of Geometry*. *21*(1).

Cuendet, S., Bonnard, Q., Do-Lenh, S., & Dillenbourg, P. (2013). Designing augmented reality for the classroom. *Computers and Education*, *68*, 557–569. https://doi.org/10.1016/j.compedu.2013.02.015

Delello, J. A. (2014). Insights from pre-service teachers using science-based augmented reality. *Journal of Computers in Education*, *1*(4), 295–311. https://doi.org/10.1007/s40692-014-0021-y

Demos, R. (1921). Memory as knowledge of the past. *The Monist*, 397–408.

Denizli, Z. A., & Erdoğan, A. (2018). Development of a three-dimensional geometric thinking test for early graders. *Journal on Mathematics Education*, *9*(2), 213–226. https://doi.org/https://doi.org/10.22342/jme.9.2.5741.213-226

Deringöl, Y. (2020). Middle school students perceptions of their self-efficacy in visual mathematics and geometry: a study of sixth to eighth grade pupils in Istanbul province, Turkey. *Education 3-13*, *48*(8), 1–12. https://doi.org/10.1080/03004279.2019.1709527

Derry, S. J. (1996). Cognitive schema theory in the constructivist debate. *Educational Psychologist*, *31*(3), 163–174. https://doi.org/10.1207/s15326985ep3103&4_2

Douglas C. Montgomery. (2009). *Design and analysis of experiment* (7th Eddition). New York: John Wiley & Sons, Inc.

Driscoll, M. (2000). Psychology of Learning for Instruction. Boston: Allyn& Bacon

Dubinsky, E., & McDonald, M. A. (2001). APOS: a constructivist theory of learning in undergraduate mathematics education research. In *The teaching and learning of mathematics at university level* (pp. 275–282). Springer, Dordrecht.

Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In *Handbook of Research on Educational Communications and Technology:*

Fourth Edition (pp. 735–745). https://doi.org/10.1007/978-1-4614-3185-5

Duval, R. (1995). Geometrical pictures: kinds of representation and specific processings. In *Exploiting mental imagery with computers in mathematics education*. Berlin: Springer Berlin Heidelberg.

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics*, *61*, 103–131. https://doi.org/10.1007/s10649-006-0400-z

Duval, R. (2017). *Understanding the mathematical way of thinking – the registers of semiotic representations*. https://doi.org/10.1007/978-3-319-56910-9

Eisenkraft, A. (2003). Expanding the 5E Model. *The Science Teacher*, *70*, 5–8.

Elmunsyah, H., Hidayat, W. N., & Asfani, K. (2019). Influence of augmented reality on the achievement and student learning independence. *Proceedings - 2019 International Seminar on Application for Technology of Information and Communication: Industry 4.0: Retrospect, Prospect, and Challenges, ISemantic 2019*, 559–563. https://doi.org/10.1109/ISEMANTIC.2019.8884279

Elsayed, S. A., & Al-najrani, H. I. (202AD). Effectiveness of the Augmented reality on improving the visual thinking in mathematics and academic motivation for middle school students. *EURASIA Journal of Mathematics, Science and Technology Education*, *17*(8), em1991.

Erdoğan, T., & Durmuş, S. (2009). The effect of the instruction based on Van Hiele model on the geometrical thinking levels of preservice elementary school teachers. *Procedia - Social and Behavioral Sciences*, *1*(1), 154–159. https://doi.org/10.1016/j.sbspro.2009.01.029

Fazelian, P., Ebrahim, A. N., & Soraghi, S. (2010). The effect of 5E instructional design model on learning and retention of sciences for middle class students. *Procedia - Social and Behavioral Sciences*, *5*, 140–143. https://doi.org/10.1016/j.sbspro.2010.07.062

Fischbein, E. (1993). The theory of figural concepts. *Educational Studies in Mathematics*, *24*(2), 139–162.

Fischbein, E., & Nachlieli, T. (1998). Concepts and figures in geometrical reasoning. *International Journal of Science Education*, *20*(10), 1193–1211. https://doi.org/10.1080/0950069980201003

Fonna, M., & Mursalim. (2018). Using of Wingeom Software in Geometry Learning to Improving the of Mathematical Representation Ability. *Malikussaleh Journal of Mathematics Learning (MJML)*, *1*(2), 40–43.

Fosnot C. T. (2005). Constructivism: Theory, Perspectives and Practice (Second Edition). Teachers College Press: Columbia University New York and London.

Fujita, T., Kondo, Y., Kumakura, H., & Kunimune, S. (2017). Students' geometric thinking with cube representations: Assessment framework and empirical evidence. *Journal of Mathematical Behavior*, *46*(June), 96–111. https://doi.org/10.1016/j.jmathb.2017.03.003

Fujita, T., Kondo, Y., Kumakura, H., Kunimune, S., & Jones, K. (2020). Spatial reasoning skills about 2D representations of 3D geometrical shapes in grades 4 to 9. *Mathematics Education Research Journal*, *32*(2), 235–255.

https://doi.org/10.1007/s13394-020-00335-w

Gao, J. (2020). Sources of mathematics self-efficacy in chinese students: a mixed-method study with Q-Sorting procedure. *International Journal of Science and Mathematics Education*, *18*(4), 713–732. https://doi.org/10.1007/s10763-019-09984-1

Gargrish, S., Kaur, D. P., Mantri, A., Singh, G., & Sharma, B. (2021). Measuring effectiveness of augmented reality-based geometry learning assistant on memory retention abilities of the students in 3D geometry. *Computer Applications in Engineering Education*, *29*(6), 1–14. https://doi.org/10.1002/cae.22424

Garzón, J., & Acevedo, J. (2019). Meta-analysis of the impact of Augmented Reality on students' learning gains. *Educational Research Review*, *27*, 244–260. https://doi.org/10.1016/j.edurev.2019.04.001

Goldin, G. A. (1998). Representational systems, learning, and problem solving in mathematics. *Journal of Mathematical Behavior*, *17*(2), 137–165. https://doi.org/10.1016/s0364-0213(99)80056-1

González, N. A. A. (2018). Development of spatial skills with virtual reality and augmented reality. *International Journal on Interactive Design and Manufacturing*, *12*(1), 133–144. https://doi.org/10.1007/s12008-017-0388-x

Gurria, A. (2016). *PISA 2015 results in focus* (Vol. 67).

Gutierrez, A. (1992). Exploring the links between Van Hiele Levels and 3-dimensional geometry. *Structural Topology*, *18*, 31–48. https://doi.org/10.1017/CBO9781107415324.004

Güven, B., & Kosa, T. (2008). The effect of dynamic geometry software on student mathematics teachers' spatial visualization skills. *The Turkish Online Journal of Educational Technology*, *7*(4), 100–107.

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education*, *20*(3), 261–273.

Hahs-Vaughn, D. L. (2017). Applied multivariate statistical concepts. In *Routledge*. https://doi.org/10.4324/9781315816685

Hailikari, T., Nevgi, A., & Lindblom-ylänne, S. (2007). Exploring alternative ways of assessing prior knowledge, its components and their relation to student achievement: a mathematics-based case study. *Studies in Educational Evaluation*, *33*, 320–337. https://doi.org/10.1016/j.stueduc.2007.07.007

Hajloo, N. (2014). Relationships between self-efficacy, self-esteem and procrastination in undergraduate psychology students. *Iranian Journal of Psychiatry and Behavioral Sciences*, *8*(3), 42–49.

Hall, S. (1997). The work of representation. In *The Applied Theatre Reader* (pp. 13–74).

Hanid, M. F. A., Mohamad Said, M. N. H., Yahaya, N., & Abdullah, Z. (2022). The elements of computational thinking in learning geometry by using augmented reality application. *International Journal of Interactive Mobile Technologies*, *16*(2), 28–41. https://doi.org/10.3991/ijim.v16i02.27295

Harel, G. (2008). What is mathematics? a pedagogical answer to a philosophical question. In *Proof and other dilemmas: Mathematics and philosophy* (pp. 285–

290).
Herbst, P., Fujita, T., Halverscheid, S., & Weiss, M. (2017). The learning and teaching of geometry in secondary schools: A modeling perspective. In *The Learning and Teaching of Geometry in Secondary Schools: A Modeling Perspective*. https://doi.org/10.4324/9781315267593
Hinton, P. R. (2014). *Statistics Explained* (Third). New York: Routledge Taylor& Francis.
Hong, D. S., Runnalls, C., & Runnalls, C. (2019). Understanding length × width × height with modified tasks. *International Journal of Mathematical Education in Science and Technology*, *51*(4), 1–12. https://doi.org/10.1080/0020739X.2019.1583383
Hsu, Y. S., Lin, Y. H., & Yang, B. (2017). Impact of augmented reality lessons on students' STEM interest. *Research and Practice in Technology Enhanced Learning*, *12*(1). https://doi.org/10.1186/s41039-016-0039-z
Huang, H.-M. E., & Witz, K. G. (2012). Children's conceptions of area measurement and their strategies for solving area measurement problems. *Journal of Curriculum and Teaching*, *2*(1), 10–26. https://doi.org/http://dx.doi.org/10.5430/jct.v2n1p10
Huang, H., & Wu, H.-Y. (2019). Supporting children's understanding of volume measurement and ability to solve volume problems: Teaching and learning. *EURASIA Journal of Mathematics, Science and Technology Education*, *15*(12), 1–36. https://doi.org/https://doi.org/10.29333/ejmste/109531
Hugues, O., Fuchs, P., & Nannipieri, O. (2011). New augmented reality taxonomy : technologies and features of augmented reality environment. In *Handbook of Augmented Reality* (pp. 47–63). https://doi.org/10.1007/978-1-4614-0064-6
Huitema, B. E. (2011). The analysis of covariance and alternatives. In *John Wiley & Sons, Inc*. https://doi.org/10.2307/2068434
Ibáñez, M. B., Uriarte Portillo, A., Zatarain Cabada, R., & Barrón, M. L. (2020). Impact of augmented reality technology on academic achievement and motivation of students from public and private Mexican schools. A case study in a middle-school geometry course. *Computers and Education*, *145*, 103734. https://doi.org/10.1016/j.compedu.2019.103734
İbili, E., Çat, M., Resnyansky, D., Şahin, S., & Billinghurst, M. (2019). An assessment of geometry teaching supported with augmented reality teaching materials to enhance students' 3D geometry thinking skills. *International Journal of Mathematical Education in Science and Technology*, *51*(2), 224–246. https://doi.org/https://doi.org/10.1080/0020739X.2019.1583382
Ilgün, M., Azak, A. Z., & Takunyaci, M. (2012). Development of self-efficacy and attitude toward analytic geometry scale (SAAG-S). *Procedia - Social and Behavioral Sciences*, *55*, 20–27. https://doi.org/10.1016/j.sbspro.2012.09.472
Isiksal, M., & Askar, P. (2005). The effect of spreadsheet and dynamic geometry software on the achievement and self-efficacy of 7th-grade students. *Educational Research*, *47*(3), 333–350. https://doi.org/10.1080/00131880500287815
Ismail, H., & Abdullah, A. H. (2020). Investigating Student's Learning Difficulties in Shape and Space Topic: A Case Study. *International Journal of*

Psychosocial Rehabilitation, *24*(5), 5315–5321. https://doi.org/10.37200/ijpr/v24i5/pr2020238

Johari, J., Sahari, J., Abd Wahab, D., Abdullah, S., Abdullah, S., Omar, M. Z., & Muhamad, N. (2011). Difficulty index of examinations and their relation to the achievement of programme outcomes. *Procedia Social and Behavioral Sciences*, *18*, 71–80. https://doi.org/10.1016/j.sbspro.2011.05.011

Johnson-Laird, P. N. (2001). Mental models and deduction. *Trends in Cognitive Sciences*, *5*(10), 434–442. https://doi.org/10.1093/jos/1.3-4.371

Johnson, R. A., & Dean W. Wicherin. (2007). *Applied Multivariate Statistical Analysis* (sixth edit). New Jersey: Pearson PrinticeHall, Inc.

Jones, K. (1998). Theoretical frameworks for the learning of geometrical reasoning. In *Proceedings of the British Society for Research into Learning Mathematics* (Vol. 18).

Jones, K. (2002). Issues in the teaching and learning of geometry. In Linda Haggarty (Ed.), *Aspects of Teaching Secondary Mathematics: perspectives on practice* (pp. 121–139). https://doi.org/10.4324/9780203165874

Kablan, Z., & Kaya, S. (2014). Preservice teachers' constructivist teaching scores based on their learning styles. *Australian Journal of Teacher Education*, *39*(12), 66–77. https://doi.org/10.14221/ajte.2014v39n12.5

Kandil, S., & Işıksal-Bostan, M. (2019). Effect of inquiry-based instruction enriched with origami activities on achievement, and self-efficacy in geometry. *International Journal of Mathematical Education in Science and Technology*, *50*(4), 557–576. https://doi.org/10.1080/0020739X.2018.1527407

Kara, M., Eames, C. L., Miller, A. L., Cullen, C. J., & Barrett, J. E. (2011). Developing an understanding of area measurement concepts with triangular units. *Proceedings of the 33rd Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.*, 1015–1023.

Kaufmann, H. (2011). Virtual Environments for Mathematics and Geometry Education. *Themes in Science and Technology Education*, 131–152. Retrieved from http://earthlab.uoi.gr/ojs/theste/index.php/theste/article/viewFile/60/42

Khairiree, K. (2020). Online Learning and Augmented Reality : Enhancing Students Learn Transformation Geometry During the Covid-19 Pandemic. *Proceedings of the 25th Asian Technology Conference in Mathematics Online*, 304–313.

Kibici, V. B. (2022). Effects of online constructivist 5E instructional model on secondary school music lessons. *International Journal of Technology in Education*, *5*(1), 117-131. https://doi.org/10.46328/ijte.241

Kimmerle, J., Moskaliuk, J., Oeberst, A., & Cress, U. (2015). Learning and collective knowledge construction with social media: a process-oriented perspective. *Educational Psychologist*, *50*(2), 120–137. https://doi.org/10.1080/00461520.2015.1036273

Kirby, J. R., & Boulter, D. R. (1999). Spatial ability and transformational geometry. *European Journal of Psychology of Education*, *14*(2), 283–294.

Klopfer, E., & Yoon, S. (2005). Developing games and simulations for today and

tomorrow's tech savvy youth. *TechTrends*, *49*(3), 33–41. https://doi.org/10.1007/bf02763645

Koester, B. A. (2003). Prisms and pyramids: constructing three-dimensional models to build understanding. *Teaching Children Mathematics*, *9*(8), 436–442. https://doi.org/https://doi.org/10.5951/TCM.9.8.0436

Kösa, T., & Karaku, F. (2010). Using dynamic geometry software Cabri 3D for teaching analytic geometry. *Procedia - Social and Behavioral Sciences*, *2*, 1385–1389. https://doi.org/10.1016/j.sbspro.2010.03.204

Kosslyn, S. M., & Thompson, W. L. (2003). When is early visual cortex activated during visual mental imagery? *Psychological Bulletin*, *129*(5), 723–746. https://doi.org/10.1037/0033-2909.129.5.723

Kusumaningrum, B., Irfan, M., & Zainnur Wijayanto. (2020). Errors analysis of students in solving volume of the solid of revolution problem in term of critical thinking aspects. *Kalamatika: Jurnal Pendidikan Matematika*, *5*(2), 119–132. https://doi.org/10.22236/kalamatika.vol5no2.2020pp119-132

Le, H. Q., & Kim, J. I. (2017). An augmented reality application with hand gestures for learning 3D geometry. *2017 IEEE International Conference on Big Data and Smart Computing, BigComp 2017*, (May), 34–41. https://doi.org/10.1109/BIGCOMP.2017.7881712

Lehrer, R. (2003). Developing understanding of measurement. In *Research companion to the principles and standards for school mathematics* (pp. 179–192).

Lin, E. L., & Murphy, G. L. (1997). Effects of background knowledge on object categorization and part detection. *Journal of Experimental Psychology: Human Perception and Performance*, *23*(4), 1153–1169. https://doi.org/10.1037/0096-1523.23.4.1153

Lin, H. K., Chen, M., & Chang, C. (2015). Assessing the effectiveness of learning solid geometry by using an augmented reality-assisted learning system. *Interactive Learning Environments*, *23*(6), 799–810. https://doi.org/10.1080/10494820.2013.817435

Liou, H., Yang, S. J. H., Chen, S. Y., & Tarng, W. (2017). The Influences of the 2D Image-Based Augmented Reality and Virtual Reality on Student Learning. *Journal of Educational Technology & Society*, *20*(3), 110–121. https://doi.org/10.2307/26196123

Lippke, S. (2017). Self-efficacy theory. In *Encyclopedia of Personality and Individual Differences* (pp. 1–6). https://doi.org/10.1007/978-3-319-28099-8

Magsalay, R. J. M., Luna, C. A., & Tan, R. G. (2019). Comparing the effect of explicit mathematics instruction with rigorous mathematical thinking approach and 5E's instructional model on students' mathematics achievement. *American Journal Of Educational Research*, *7*(6), 402–406. https://doi.org/10.12691/education-7-6-5

Mammarella, I. C., Giofrè, D., & Caviola, S. (2017). Learning geometry: the development of geometrical concepts and the role of cognitive processes. In *Acquisition of Complex Arithmetic Skills and Higher-Order Mathematics Concepts* (pp. 221–246). https://doi.org/10.1016/B978-0-12-805086-6/00010-2

Marchis, I. (2012). Preservice primary school teachers' elementary geometry knowledge. *Acta Didactica Napocensia*, *5*(2), 33–40.

Mariotii, M. A. (1989). Mental images: some problems related to the development of solids. *Proceedings of the 13rd International Conference for the Psychology of Mathematics Education*. https://doi.org/10.1158/1535-7163.mct-16-0142

Markopoulos, C., Chaseling, M., Petta, K., Lake, W., & Boyd, W. (2015). Pre-service teachers' 3D visualization strategies. *Creative Education*, *6*(10), 1053–1059. https://doi.org/10.4236/ce.2015.610104

Martinovic, D. (2020). Teachers using GeoGebra to visualize and verify conjectures about trapezoids. *Canadian Journal of Science, Mathematics and Technology Education*, *20*(3), 485–503.

Mason, M. (2009). The van Hiele levels of geometric understanding. *Colección Digital Eudoxus*, *1*(2).

Mayberry, J. (1983). The Van Hiele Levels of geometric thought in undergraduate preservice teachers. *Journal for Research in Mathematics Education*, *14*(1), 58–69.

McGee, M. G. (1979). Human Spatial Abilities: Psychometric Studies and Environmental, Genetic, Hormonal, and Neurological Influences. *Psychological Bulletin*, *86*(5), 889–918. https://doi.org/10.1103/PhysRevD.78.096002

Mesquita, A. L. (1998). On conceptual obstacles linked with external representation in geometry. *Journal of Mathematical Behavior*, *17*(2), 183–195. https://doi.org/https://doi.org/10.1016/S0364-0213(99)80058-5

Mitchelmore, M. C. (1980). Prediction of developmental Stages in the representation of representation of regular space figures. *Journal for Research in Mathematics Education*, *11*(2), 83–93. https://doi.org/https://doi.org/10.2307/748901

Moerkerke, G., & Dochy, F. J. R. C. (1998). Effects of prior knowledge state assessment and progress assessment on study results in independent learning. *Studies in Educational Evaluation*, *24*(2), 179–201. https://doi.org/10.1016/S0191-491X(98)00010-8

Mohamadi, F. S., Asadzadeh, H., Ahadi, H., & Jomehri, F. (2011). Testing Bandura's Theory in school. In *Procedia - Social and Behavioral Sciences* (Vol. 12, pp. 426–435). https://doi.org/10.1016/j.sbspro.2011.02.053

Mostafa, M., Mohammad Javad, L., & Reza, O. H. (2016). The Effect of Van Hiele theory-based teaching educational package on achievement goal orientation of student teachers. *Review of European Studies*, *9*(1), 93. https://doi.org/10.5539/res.v9n1p93

Moyer, P. S. (2001). Using representations to explore perimeter and area. *Teaching Children Mathematics*, *8*(1), 52–59. https://doi.org/10.5951/TCM.8.1.0052

Mulligan, J., Woolcott, G., Mitchelmore, M., Busatto, S., Lai, J., & Davis, B. (2020). Evaluating the impact of a Spatial Reasoning Mathematics Program (SRMP) intervention in the primary school. *Mathematics Education Research Journal*, *32*(2), 285–305. https://doi.org/10.1007/s13394-020-00324-z

Mullis, I.V.S, Martin, M. O., & Foy, P. (2008). TIMSS 2007 International Mathematics Report. In *International Association for the Evaluation of*

Educational Achievement (IEA) Published. Retrieved from http://isc.bc.edu/timss2003i/mathD.html

Mullis, Ina V.S, Martin, M. O., Foy, P., & Arora, A. (2011). *TIMSS 2011 International Results in Mathematics*. Boston: TIMSS & PIRLS International Study Center.

Mullis, Ina V.S, Martin, M. O., Foy, P., & Hooper, M. (2015). *TIMSS 2015 International Results in Mathematics*. Retrieved from http://timss2015.org/timss-2015/science/student-achievement/distribution-of-science-achievement/

Munzil, M., & Mentari, P. R. A. (2021). Development of e-learning teaching material with augmented reality based on problem based learning for nature of chemistry and scientific methods topic as teaching material in Covid-19 pandemic. *AIP Conference Proceedings*, *2330*. https://doi.org/10.1063/5.0043248

Nasrudin, N. H., Azfar, M. H., Hatta, M., Azmi, A. Z., & Junid, R. A. (2021). Mobile application: learning basic mathematics operation using augmented reality. *Mathematical Sciences and Informatics Journal*, *2*(1), 9–20. Retrieved from http://www.mijuitmjournal.com

NCTM. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Ng, O. L., Shi, L., & Ting, F. (2020). Exploring differences in primary students' geometry learning outcomes in two technology-enhanced environments: dynamic geometry and 3D printing. *International Journal of STEM Education*, *7*(1), 1–13. https://doi.org/10.1186/s40594-020-00244-1

Nguyen, N.-G. (2021). Applying 5E teaching model in recognizing regular polygons and rotations with the help of GeoGebra software. Advances in Social Sciences Research Journal, 8(8), 380–399. https://doi.org/10.14738/assrj.88.10672

Nguyen, N., & Phan, A. (2015). Building the process of transformation teaching and learning according to the constructivism with the help of dynamic geometry software in Vietnam. *International Journal of Learning*, *10*(1), 120–141.

Ninio, A. (1979). Piaget's theory of space perception in infancy. *Cognition*, *7*(2), 125–144. https://doi.org/10.1016/0010-0277(79)90017-9

Noordyana, M. A., Maryati, I., Sumartini, T. S., Sofyan, D., & Sundayana, R. (2019). *Wingeom program in geometry*. https://doi.org/10.1088/1742-6596/1402/7/077093

Nursyamsiah, G., Savitri, S., Yuspriyati, D. N., & Zanthy, L. S. (2020). Analisis kesulitan siswa SMP kelas VIII dalam menyelesaikan soal materi bangun ruang sisi datar. *Maju*, *7*(1), 98–102.

Olalde, K., García, B., & Seco, A. (2013). The importance of geometry combined with new techniques for augmented reality . *Procedia - Procedia Computer Science*, *25*, 136–143. https://doi.org/10.1016/j.procs.2013.11.017

Omotayo, S. A., & Adeleke, J. O. (2017). The 5E instructional model: a constructivist approach for enhancing students' learning outcomes in mathematics. *Journal of the International Society for Teacher Education*,

21(2), 15–26.

Önal, N., Ibili, E., & Çaliskan, E. (2017). Does teaching geometry with augmented reality affect the technology acceptance of elementary school mathematics teacher candidates?. *Journal of Education and Practice*, *8*(19), 151–163.

Ozdamli, F., & Hursen, C. (2017). An emerging technology: Augmented reality to promote learning. *International Journal of Emerging Technologies in Learning*, *12*(11), 121–137. https://doi.org/10.3991/ijet.v12.i11.7354

Özdemir, A. Ş., Karaşan, S., & Şahal, M. (2021). An examination of the relationship between secondary school students' abstract thinking skills, self-efficacy perceptions and attitudes towards mathematics. *Participatory Educational Research*, *8*(2), 391–406. https://doi.org/10.17275/per.21.45.8.2

Özerem, A. (2012). Misconceptions in geometry and suggested solutions for seventh grade students. *International Journal of New Trends in Arts, Sports & Science Education*, *1*(4), 23–35. https://doi.org/10.1016/j.sbspro.2012.09.557

Özyıldırım Gümüş, F., Zeybek, N., & Aydın, Ş. (2021). Teaching geometry with different activities to investigate the students' perceptions, attitudes and self-efficacies. *International Online Journal of Education and Teaching*, *8*(2), 1083–1105.

Pampaka, M., Kleanthous, I., & Hutcheson, G. D. (2011). Research in mathematics education measuring mathematics self-efficacy as a learning outcome. *Research in Mathematics Education*, *13*(2), 169–190. https://doi.org/10.1080/14794802.2011.585828

Parzysz, B. (1988). "Knowing" vs "Seeing". Problems of the Plane Representation of Space Geometry Figures. *Educational Studies in Mathematics*, *19*(1), 79–92.

Parzysz, B. (1991). Representation of space and students'conceptions at high school level. *Educational Studies in Mathematics*, *22*, 575–593.

Pavlovičová, G., & Švecová, V. (2015). The development of spatial skills through discovering in the geometrical education at primary school. *Procedia - Social and Behavioral Sciences*, *186*, 990–997. https://doi.org/10.1016/j.sbspro.2015.04.189

Pittalis, M., & Christou, C. (2010). Types of reasoning in 3D geometry thinking and their relation with spatial ability. *Educational Studies in Mathematics*, *75*(2), 191–212. https://doi.org/10.1007/s10649-010-9251-8

Pittalis, M., & Christou, C. (2013). Coding and decoding representations of 3D shapes. *Journal of Mathematical Behavior*, *32*(3), 673–689. https://doi.org/10.1016/j.jmathb.2013.08.004

Pittalis, M., Mousoulides, N., & Christou, C. (2010). Students' 3D geometry thinking profiles. *Proceedings of CERME6*, 816–825. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1074.8742&rep=rep1&type=pdf

Rahardjoni, A. S., Hasanah, I. N., & Nugraheni, M. S. (2020). Developing critical thinking competence in algebraic thinking using augmented reality for junior high school. *PRISMA: Prosiding Seminar Nasional Matematika*, *3*, 497–503.

Ramaligela, S. M., Ogbonnaya, U. I., & Mji, A. (2019). Comparing pre-service teachers' pck through 9e instructional practice : a case of mathematics and

technology pre-service teachers. *Africa Education Review*, *16*(3), 101–116. https://doi.org/10.1080/18146627.2016.1241668

Raykov, T., & Marcoulides, G. A. (2008). *An Introduction to Applied Multivariate Analysis*. New York: Routledge.

Reece, C. S., & Kamii, C. (2000). The measurement of volume: Why do young children measure inaccurately? *School Science and Mathematics*, *101*(7), 356–361. https://doi.org/https://doi.org/10.1111/j.1949-8594.2001.tb17969.x

Reeve, J. (2008). *Understanding Motivation and Emotion*. John Wiley & Sons.

Richard R. Hake. (1999). *Analyzing Change/Gain Scores* (pp. 1–4). pp. 1–4. Retrieved from http://www.physics.indiana.edu/~sdi/AnalyzingChange-Gain.pdf.

Roblyer, M. . (2016). *Integrating Educational Technology into Teaching*. United States of America: Pearson Education Limited.

Rohendi, D., Septian, S., & Sutarno, H. (2018). The use of geometry learning media based on augmented reality for junior high school students. *IOP Conference Series: Materials Science and Engineering*, *306*(1). https://doi.org/10.1088/1757-899X/306/1/012029

Rohendi, D., & Wihardi, Y. (2020). Learning three-dimensional shapes in geometry using mobile-based augmented reality. *International Journal of Interactive Mobile Technologies*, *14*(9), 48–60.

Roth, W., & Thom, J. S. (2009). The emergence of 3D geometry from children's (teacher-guided) classification tasks. *Journal of the Learning Sciences*, *18*(1), 44–99. https://doi.org/http://dx.doi.org/10.1080/10508400802581692

Rovetto, R. J. (2011). The shape of shapes: An ontological exploration. *Shapes*, *1*.

Şahin, S. M. S., & Baturay, M. H. (2016). The effect of 5E-learning model supported with WebQuest media on students' achievement and satisfaction. E-Learning and Digital Media, 13(3–4), 158–175. https://doi.org/10.1177/2042753016672903

Safar, A. H., Al-Jafar, A. A., & Al-Yousefi, Z. H. (2017). The effectiveness of using augmented reality apps in teaching the english alphabet to kindergarten children: A case study in the state of Kuwait. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(2), 417–440. https://doi.org/10.12973/eurasia.2017.00624a

Salmi, H., Kaasinen, A., & Kallunki, V. (2012). Towards an open learning environment via augmented reality (AR): visualising the invisible in science centres and schools for teacher education. *Procedia - Social and Behavioral Sciences*, *45*, 284–295. https://doi.org/10.1016/j.sbspro.2012.06.565

Sampaio, D., & Almeida, P. (2016). Pedagogical strategies for the integration of Augmented Reality in ICT teaching and learning processes. *Procedia Computer Science*, *100*, 894–899. https://doi.org/10.1016/j.procs.2016.09.240

Sarama, J., & Clements, D. H. (2009). Early childhood mathematics education research: Learning trajectories for young children. In *Learning and Teaching Early Math: The Learning Trajectories Approach*. https://doi.org/10.4324/9780203883785

Sarkar, P., Kadam, K., & Pillai, J. S. (2020). Learners' approaches, motivation and patterns of problem-solving on lines and angles in geometry using augmented

reality. *Smart Learning Environments*, *7*(1), 1–23.

Saundarajan, K., Osman, S., Daud, M. F., Abu, M. S., Pairan, M. R., & Kumar, J. A. (2020). Learning algebra using augmented reality: A Preliminary Investigation on the Application of Photomath for Lower Secondary Education. *International Journal of Emerging Technologies in Learning*, *15*(16), 123–133. https://doi.org/10.3991/ijet.v15i16.10540

Schacht, F., & Swidan, O. (2020). Exploring pre-calculus with augmented reality. A design-based-research approach. *Eleventh Congress of the European Society for Research in Mathematics Education (No. 27). Freudenthal Group; Freudenthal Institute; ERME.*, 02428775.

Schallert, S., & Lavicza, Z. (2020). Implementing augmented reality in flipped mathematic classrooms to enable inquiry-based learning. *Proceedings of 14 Th International Conference on Technology in Mathematics Teaching*, 1–8. https://doi.org/10.17185/duepublico/70747

Schallert, Stefanie, & Lavicza, Z. (2016). Implementing augmented reality in flipped mathematic classrooms to enable inquiry-based learning. *Conference on Technology in Mathematics Teaching*, 1–9.

Schiavi, B., & Gechter, F. (2010). Teach me a story: an augmented reality application for teaching history in middle school. *2010 2nd International Conference on Computer Engineering and Applications, ICCEA 2010*, *2*, 461–465. https://doi.org/10.1109/ICCEA.2010.239

Schneider, W. X. (1999). Visual-spatial working memory, attention, and scene representation: A neuro-cognitive theory. *Psychological Research*, *62*(2–3), 220–236. https://doi.org/10.1007/s004260050052

Segal, R., Stupel, M., Sigler, A., & Jahangiril, J. (2018). The effectiveness of 'what if not' strategy coupled with dynamic geometry software in an inquiry- based geometry classroom. *International Journal of Mathematical Education in Science and Technology*, *49*(7), 1099–1109. https://doi.org/10.1080/0020739X.2018.1452302

Serin, H. (2018). Perspectives on the teaching of geometry: teaching and learning methods. *Journal of Educational and Training*, *5*(1), 131–137. https://doi.org/10.5296/jet.v5i1.xxxx

Sharma, H. L., & Nasa, G. (2014). Academic self-efficacy : a reliable predictor of educational performaces. *British Journal of Education*, *2*(3), 57–64.

Shing, Y. L., & Brod, G. (2016). Effects of prior knowledge on memory: implications for education. *mind, brain, and education*, *10*(3), 153–161. https://doi.org/10.1111/mbe.12110

Sickel, A. J. (2017). The 5E model as a framework for facilitating multiple teacher education outcomes. *Designing and Teaching the Secondary Science Methods Course*, 11–31. https://doi.org/10.1007/978-94-6300-881-5_2

Sidney, P. G., & Alibali, M. W. (2015). Making connections in math: activating a prior knowledge analogue matters for learning. *Journal of Cognition and Development*, *16*(1), 160–185. https://doi.org/10.1080/15248372.2013.792091

Siltanen, S. (2012). Theory and applications of marker-based augmented reality. In *JULKAISIJA - UTGIVARE-PUBLISHER*. Retrieved from

http://www.vtt.fi/publications/index.jsp

Sinclair, N., & Bruce, C. D. (2015). New opportunities in geometry education at the primary school. *ZDM Mathematics Education*, *47*(3), 319–329. https://doi.org/10.1007/s11858-015-0693-4

Sirakaya, M., & Cakmak, E. K. (2018). Effects of augmented reality on student achievement and self-efficacy in vocational education and training. *International Journal for Research in Vocational Education and Training*, *5*(1), 1–18. https://doi.org/10.13152/IJRVET.5.1.1

Sollervall, Håk. (2012). Collaborative mathematical inquiry with augmented reality. *Research & Practice in Technology Enhanced Learning*, *7*(3), 153–173. Retrieved from http://ezproxy.lib.swin.edu.au/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=90546527&site=ehost-live&scope=site

Stajkovic, A., & Luthans, F. (2003). Social cognitive theory and self-efficacy : implications for motivation theory and practice. *Motivation and Work Behavior*, 126–140.

Stylianou, D. A. (2011). An examination of middle school students' representation practices in mathematical problem solving through the lens of expert work : towards an organizing scheme. *Educational Studies in Mathematics*, *76*(3), 265–280. https://doi.org/10.1007/s10649-010-9273-2

Sudirman, S., & Martadiputra, B. A. P. (2020). Exploratory case study kesulitan siswa sekolah menengah pertama dalam menyelesaikan permasalahan luas permukaan limas. *Math Didactic: Jurnal Pendidikan Matematika*, *6*(3), 277–286.

Sun, K. T., & Chen, M. H. (2019). Utilizing free augmented reality app for learning geometry at elementary school in taiwan : take volumetric measurement of compound body for example. *International Journal of Distance Education Technologies*, *17*(4), 36–53. https://doi.org/10.4018/IJDET.2019100103

Sun, K. T., & Chen, M. H. (2020). Utilizing MAR for remedial teaching of compound-cube-surface area at elementary school in taiwan. *International Journal of Information and Communication Technology Education*, *16*(2), 18–35. https://doi.org/10.4018/IJICTE.2020040102

Sun, M., Wu, X., Fan, Z., & Dong, L. (2019). Augmented reality based educational design for children. *International Journal of Emerging Technologies in Learning*, *14*(3), 51–60. https://doi.org/10.3991/ijet.v14i03.9757

Tan-sisman, G., & Aksu, M. (2016a). A study on sixth grade students' misconceptions and errors in spatial measurement: Length, area, and volume. *International Journal of Science and Mathematics Education*, *14*(7), 1293–1319. https://doi.org/10.1007/s10763-015-9642-5

Tan-sisman, G., & Aksu, M. (2016b). A Study on sixth grade students ' misconceptions and errors in spatial measurement: length, area, and volume. *International Journal of Science and Mathematics Education14*, *14*(7), 1293–1319. https://doi.org/10.1007/s10763-015-9642-5

Taylor, P., Koklu, O., & Topcu, A. (2013). Effect of cabri-assisted instruction on secondary school students' misconceptions about graphs of quadratic functions. *International Journal of Mathematical Education in Science and*

Technology, *43*(8), 999–1011.

Tezer, M., & Cumhur, M. (2017). Mathematics through the 5E instructional model and mathematical modelling: the geometrical objects. *EURASIA Journal of Mathematics Science and Technology Education*, *13*(8), 4789–4804. https://doi.org/10.12973/eurasia.2017.00965a

Tobias, S. (1994). Interest, prior knowledge, and learning. *Review of Educational Research*, *64*(1), 37–54.

Toomela, A. (1999). Drawing development: Stages in the representation of a cube and a cylinder. *Child Development*, *70*(5), 1141–1150. https://doi.org/10.1111/1467-8624.00083

Tornero Ochagavia, B. (2017). the Impact of a socio-constructivist approach on prospective primary teachers' attitudes about teaching and learning in general and mathematics in particular. *Paginas De Educacion*, *10*(1), 1–35. https://doi.org/10.22235/pe.v10i1.1357

Tsai, M., & Lee, K. (2006). A study of knowledge internalization : from the perspective of learning cycle theory. *Journal of Knowledge Management*, *10*(3), 57–71. https://doi.org/10.1108/13673270610670858

Tůmová, V., & Vondrová, N. (2017). Links between success in non-measurement and calculation tasks in area and volume measurement and pupils ' problems [Vztah mezi úspěšností v nenumerických a numerických úlohách na obsah a objem a žákovské problémy Theoretical framework and related literatu]. *Scientia in Educatione*, *8*(2), 100–129.

Tuna, A., & Kacar, A. (2013). The effect of 5E learning cycle model in teaching trigonometry on students' academic achievement and the permanence of their knowledge. *International Journal on New Trends in Education and Their Implications*, *4*(1), 73–87.

Turan, S., & Matteson, S. M. (2021). Middle school mathematics classrooms practice based on 5e instructional model. *International Journal of Education in Mathematics, Science and Technology*, *9*(1), 22–39. https://doi.org/10.46328/ijemst.1041

Ula, N., Munzil, Setiawan, A. M., & Sugiyanto. (2021). Development of teaching material solar system using learning cycle 7E model completed with augmented reality. *AIP Conference Proceedings*, *2330*(March). https://doi.org/10.1063/5.0043272

Ullman, S. (1980). Against direct perception. *Behavioral and Brain Sciences*, *3*(3), 373–381. https://doi.org/10.1017/S0140525X0000546X

Ünlü, M., Avcu, S., & Avcu, R. (2010). The relationship between geometry attitudes and self-efficacy beliefs towards geometry. *Procedia - Social and Behavioral Sciences*, *9*, 1325–1329. https://doi.org/10.1016/j.sbspro.2010.12.328

Urifah, P., Munzil, Pratiwi, N., & Yulianti, E. (2021). Interactive teaching materials using learning cycle 5E equipped with augmented reality on human respiratory system. *AIP Conference Proceedings*, *2330*(March), 2–8. https://doi.org/10.1063/5.0043274

Vasilyeva, M., Ganley, C. M., Casey, B. M., Dulaney, A., Tillinger, M., & Anderson, K. (2012). How children determine the size of 3D structures:

Investigating factors influencing strategy choice. *Cognition and Instruction*, *31*(1), 29–61. https://doi.org/10.1080/07370008.2012.742086

Vergnaud, G. (1998). A comprehensive theory of representation for mathematics education. *Journal of Mathematical Behavior*, *17*(2), 167–181. https://doi.org/10.1016/s0364-0213(99)80057-3

VKRP (Virginia Kindergarten Readiness Program). (2018). *Skill: Shape Recognition and Properties*.

Voulgaris, S., & Evangelidou, A. (2002). *Understanding of three-dimensional arrays of cubes - Children in transition*.

Wahab, R. A., Abdullah, A. H., Abu, M. S., Moktar, M. B., & Atan, N. A. B. (2016). A case study on visual-spatial skills and level of geometric thinking in learning 3D geometry among high achievers. *Man in India*, *92*(1), 489–499.

Waleed, Z., Ababneh, M., Bawaneh, A. K., Mohammad, W., & Alzubi, M. (2019). Effect of Augmented Reality and Simulation on the Achievement of Mathematics and Visual Thinking Among Students. *International Journal of Emerging Technologies in Learning (IJET)*, *14*(18), 164–185.

Wang, M., Callaghan, V., Bernhardt, J., & White, K. (2018). Augmented reality in education and training : pedagogical approaches and illustrative case studies. *Journal of Ambient Intelligence and Humanized Computing*, *9*(5), 1391–1402. https://doi.org/10.1007/s12652-017-0547-8

Wipawayangkool, K., & Teng, J. T. C. (2016). Assessing Tacit Knowledge and Sharing Intention: A Knowledge Internalization Perspective. *Knowledge and Process Management*, *23*(3), 194–206. https://doi.org/10.1002/kpm.1505

Yang, X., Kaiser, G., König, J., & Blömeke, S. (2020). Relationship between pre-service mathematics teachers' knowledge, beliefs and instructional practices in China. *ZDM - Mathematics Education*, *52*(2), 281–294. https://doi.org/10.1007/s11858-020-01145-x

Yanik, H. B. (2011). Prospective middle school mathematics teachers ' preconceptions of geometric translations. *Educational Studies in Mathematics*, *78*, 231–260. https://doi.org/10.1007/s10649-011-9324-3

Yea-Ling Tsao. (2018). The effect of constructivist instructional-based mathematics course on the attitude toward geometry of pre-service elementary school teachers. *US-China Education Review A*, *8*(1), 1–10. https://doi.org/10.17265/2161-623x/2018.1.001

Yuen, S. C.-Y., Yaoyuneyong, G., & Johnson, E. (2011). Augmented reality: an overview and five directions for AR in education. *Journal of Educational Technology Development and Exchange*, *4*(1). https://doi.org/10.18785/jetde.0401.10

Yuksel, I., Celiker, G., & Soy, Y. (2013). The examination of high school students' geometry self-efficacy beliefs. *International Journal of Academic Research*, *5*(6), 41–45. https://doi.org/10.7813/2075-4124.2013/5-6/b.8

Zhang, Jiajie. (1997). The nature problem of external in solving representations. *Cognitive Science*, *21*(2), 179–217.

Zhang, Jiawei. (2019). Cognitive functions of the brain: perception, attention, and memory. *ArXiv*.

Zhang, Q. (2021). Opportunities to learn three-dimensional shapes in primary

mathematics: the case of content analysis of primary mathematics textbooks in Hong Kong. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(6), 1–15. https://doi.org/10.29333/ejmste/10884

Zulnaidi, H., Oktavika, E., & Hidayat, R. (2019). Effect of use of GeoGebra on achievement of high school mathematics students. *Education and Information Technologies*, *25*(1), 51–71.