Coding Scheme

Variable	Code	Description	Examples
Authors		Authors' names	
# in data set	1–130		
Publication year	2018–2022		
Country		ISO code of country of affiliation of first author	USA, SWE, GER, …
Publication type	Artic Conf	Journal article Conference proceedings	
Journal type	Math Psy STEM SpEd	Mathematics education journal Education/psychology journal Interdisciplinary scientific journal Special needs education journal	Mathematical Thinking and Learning Applied Cognitive Psychology International Journal of STEM Education Exceptionality
Research methods	Quan Qual n/a	Quantitative methods Qualitative methods Not mentioned, not applicable	(Quasi-)Experimental, correlational Case study, grounded theory
Participants' level of education	Pre Elem Secon Univ Preserv Inserv n/a	Preschool children Elementary school students Secondary school students (5-12) Mathematics university students Preservice (mathematics) teachers Inservice mathematics teachers Not mentioned, not applicable	
Sample size	0–50 51–100 101–200 201–500 501–1000 >1000 n/a	 Not mentioned, not applicable	-
Component	Prod Proc n/a	Primarily visualization product Primarily visualization process Not mentioned, not applicable	Number, type, accuracy of visualization Use of vis. (frequency, length of time)
Type	Pic Schem Leng Area Rel n/a	Pictorial visualization Schematic visualization Length visualization Area visualization Relational visualization Not mentioned, not applicable	Photograph, situational drawing Figures, shapes Number line, bar graph Pie chart, Venn diagram Tree diagram, table, concept map
Tool use	Pap Tech Gest Obj n/a	Paper Technology-based Gestures Handy-on objects Not mentioned, not applicable	Paper-pencil use Geogebra, Excel, Augmented Reality Gestures, movements Base-ten blocks, real-world objects
Content-related purpose	Num Ana Alg Geo Sto Log n/a	Numbers and operations Analysis Algebra Geometry Stochastic and data analysis Logic and set theory Not mentioned, not applicable	Fractions, multiplication Functions, calculus Equations, inequalities Figures, objects Probabilities Propositional logic
Process-related purpose	Und Prob Mod Proof Teach n/a	Understanding Problem solving and posing Mathematical modelling Arguing and proofing Teaching Not mentioned, not applicable	Understanding, reasoning, thinking Problem solving and posing Modelling Proof construction Explaining to students, assessment

Exemplary Coding

Variable	Code	Exemplary study 1	Exemplary study 2
Authors		Kobiela, M., & Lehrer, R.	Rellensmann, J., Schukajlow, S., Blomberg, J., & Leopold, C.
Number in data set	1–130	59	99
Publication year	2018–2022	2019	2022
Country		CAN	GER
Publication type	Artic	1	1
	Conf	0	0
Journal type	Math	1	1
	Psy	0	0
	STEM	0	0
	SpEd	0	0
Research methods	Quan	0	1
	Qual	1	1
	n/a	0	0
Participants' level of education	Pre	0	0
	Elem	0	0
	Secon	1	1
	Univ	0	0
	Preserv	0	0
	Inserv	0	0
	n/a	0	0
Sample size	0–50	1	0
	51–100	0	0
	101–200	0	1
	201–500	0	0
	501–1000	0	0
	>1000	0	0
	n/a	0	0
Component	Prod	0	0
	Proc	1	0
	n/a	0	1
Type	Pic	0	1
	Schem	1	1
	Leng	0	0
	Area	0	0
	Rel	0	0
	n/a	0	0
Tool use	Pap	1	1
	Tech	0	0
	Gest	1	0
	Obj	0	0
	n/a	0	0
Content-related purpose	Num	0	0
	Ana	0	0
	Alg	0	0
	Geo	1	1
	Sto	0	0
	Log	0	0
	n/a	0	0
Process-related purpose	Und	1	0
	Prob	0	0
	Mod	0	1
	Proof	0	0
	Teach	0	0
	n/a	0	0

Included Studies

Adams, S. R., & Maki, K. E. (2020). Examining the differential effectiveness and efficiency of alternative multiplication drill interventions with third-grade students. *Journal of Applied School Psychology*, *37*(4), 352–376. https://doi.org/10.1080/15377903.2020.1848956

Albin, S., & Brown, B. (2019). Developing Namibian grade 8 learners' conceptions of fractions using visual models. *African Journal of Research in Mathematics, Science and Technology Education*, *23*(2), 206–218. https://doi.org/10.1080/18117295.2019.1658443

Aldalalah, O., Ababneh, Z. W., Bawaneh, A. K., & Alzubi, W. 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*, *14*(18), 164–185. https://doi.org/10.3991/ijet.v14i18.10748

Alkhateeb, M. (2019). Multiple representations in 8th grade mathematics textbook and the extent to which teachers implement them. *International Electronic Journal of Mathematics Education*, *14*(1), 137–145.

Amevor, G., Bayaga, A., & Bosse, M. J. (2021). Analysis of rural-based pre-service teachers spatial-visualisation skills in problem solving in vector calculus using MATLAB. *International Journal for Emerging Technologies in Learning*, *16*(10), 125–149. https://doi.org/10.3991/ijet.v16i10.19269

Awuah, F. K., & Ogbonnaya, U. I. (2020). Grade 12 students' proficiency in solving probability problems involving contingency tables and tree diagrams. *International Journal of Instruction*, *13*(2), 819–834. https://doi.org/10.29333/iji.2020.13255a

Aydin, H., & Monaghan, J. (2018). Encouraging students' problem posing through importing visual images into mathematical software. *Teaching Mathematics and Its Applications*, *37*(3), 141–154. https://doi.org/10.1093/teamat/hrx005

Baccaglini-Frank, A. E., Santi, G., Del Zozzo, A., & Frank, E. (2020). Teachers' perspectives on the intertwining of tangible and digital modes of activity with a drawing robot for geometry. *Education Sciences*, *10*(12). https://doi.org/10.3390/educsci10120387

Bakar, K. A., Yunus, F., Mohamed, S., & Karim, A. A. (2020). Addition concept through the lenses of young children: Creating visual representation with digital cameras. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(6), 1–11. https://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2020-53293-009&lang=de&site=ehost-live

Barbosa, A., & Vale, I. (2021). A visual approach for solving problems with fractions. *Education Sciences*, *11*(11). https://doi.org/10.3390/educsci11110727

Bennett, A., Inglis, M., & Gilmore, C. (2019). The cost of multiple representations: Learning number symbols with abstract and concrete representations. *Journal of Educational Psychology*, *111*(5), 847–860. https://doi.org/10.1037/edu0000318

Bernard, M., & Senjayawati, E. (2019). Developing the students' ability in understanding mathematics and self-confidence with VBA for Excel. *Journal of Research and Advances in Mathematics Education*, *4*(1), 45–56. https://journals.ums.ac.id/index.php/jramathedu/article/view/6349/4440

Bhagat, K. K., Yang, F.-Y., Cheng, C.-H., Zhang, Y., & Liou, W.-K. (2021). Tracking the process and motivation of math learning with augmented reality. *Educational Technology Research and Development*, *69*(6), 3153–3178. 10.1007/s11423-021-10066-9

Björklund, C., & Palmér, H. (2020). Preschoolers' reasoning about numbers in picture books. *Mathematical Thinking and Learning*, *22*(3), 195–213. https://doi.org/10.1080/10986065.2020.1741334

Borji, V., & Sánchez, A. (2019). An exploratory analysis of the representations of functions in the university entrance exam in Spain and Iran. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(8). https://doi.org/10.29333/ejmste/106258

Bronkhorst, H., Roorda, G., Suhre, C., & Goedhart, M. (2021). Student development in logical reasoning: Results of an intervention guiding Students through different modes of visual and formal representation. *Canadian Journal of Science, Mathematics and Technology Education*, *21*(2), 378–399. https://doi.org/10.1007/s42330-021-00148-4

Brooks, N. B., Barner, D., Frank, M., & Goldin-Meadow, S. (2018). The role of gesture in supporting mental representations: The case of mental Abacus arithmetic. *Cognitive Science*, *42*(2), 554–575.

Bullock, E. P., Webster, J. S., & Jones, D. L. (2021). Helpful and hindering features of GeoGebra: Understanding what affords conceptual understandings of definite integrals among pre-service middle grades mathematics teachers. *International Journal for Technology in Mathematics Education*, *28*(2), 81–92. https://doi.org/10.1564/tme_v28.2.02

Buncher, A., Hord, C., Weaver, K., & Gamel, Z. (2019). Visual representations and verbal schemas: A case study of one student with high-functioning autism. *Journal of Research in Special Educational Needs*, *19*(2), 79–91. https://doi.org/10.1111/1471-3802.12426

Caglayan, G. (2018). Coordinating analytic and visual approaches: Math majors' understanding of orthogonal Hermite polynomials in the inner product space $\mathbb{P}n$ ($\mathbb{R}$) in a technology-assisted learning environment. *The Journal of Mathematical Behavior*, *52*, 37–60. https://doi.org/10.1016/j.jmathb.2018.03.006

Çekmez, E. (2020). Establishing the link between the graph of a parametric curve and the derivatives of its component functions. *International Journal of Mathematical Education in Science and Technology*, *51*(1), 115–130. https://doi.org/10.1080/0020739X.2019.1663950

Çekmez, E. (2021). Investigating the effect of computer-supported instruction on students' understanding of different representations of two-variable inequalities. *Interactive Learning Environments.* Advance online publication. https://doi.org/10.1080/10494820.2021.1926288

Cheeseman, J., Downton, A., Roche, A., & Ferguson, S. (2020). Investigating young students' multiplicative thinking: The 12 little ducks problem. *Journal of Mathematical Behavior*, *60.* https://doi.org/10.1016/j.jmathb.2020.100817

Chen, Y. (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

Clemente, F., & Fortuny, J. M. (2021). Egyptian fractions and representation registers in the construction of the fraction concept. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(7). https://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2021-72993-001&lang=de&site=ehost-live

David, E. J., Roh, K. H., & Sellers, M. E. (2019). Value-thinking and location-thinking: Two ways students visualize points and think about graphs. *The Journal of Mathematical Behavior*, *54.* https://doi.org/10.1016/j.jmathb.2018.09.004

DeJarnette, A. F. (2018). Students' conceptions of sine and cosine functions when representing periodic motion in a visual programming environment. *Journal for Research in Mathematics Education*, *49*(4), 390–423. https://doi.org/10.5951/jresematheduc.49.4.0390

Dello Iacono, U., & Dentice, E. F. Mathematical walks in search of symmetries: From visualization to conceptualization. *International Journal of Mathematical Education in Science and Technology.* Advance online publication. https://doi.org/10.1080/0020739X.2020.1850897

Dimmel, J. K., & Pandiscio, E. A. (2020). When it's on zero, the lines become parallel: Preservice elementary teachers' diagrammatic encounters with division by zero. *Journal of Mathematical Behavior*, *58.* https://doi.org/10.1016/j.jmathb.2020.100760

Ding, M., Chen, W., & Hassler, R. S. (2019). Linear quantity models in US and Chinese elementary mathematics classrooms. *Mathematical Thinking and Learning*, *21*(2), 105–130. https://doi.org/10.1080/10986065.2019.1570834

Dockendorff, M., & Solar, H. (2018). Ict integration in mathematics initial teacher training and its impact on visualization: The case of GeoGebra. *International Journal of Mathematical Education in Science and Technology*, *49*(1), 66–84. https://doi.org/10.1080/0020739X.2017.1341060

Earnest, D. (2022). About time: Syntactically-guided reasoning with analog and digital clocks. *Mathematical Thinking and Learning*, *24*(1), 70–89. https://doi.org/10.1080/10986065.2021.1881703

Emerson, R. W., & Anderson, D. (2018). What mathematical images are in a typical mathematics textbook? Implications for students with visual impairments. *Journal of Visual Impairment & Blindness*, *112*(1), 20–32.

Flores, M. M., & Hinton, V. M. (2019). Improvement in elementary students' multiplication skills and understanding after learning through the combination of the concrete-representational-abstract sequence and strategic instruction. *Education & Treatment of Children*, *42*(1), 73–99. https://doi.org/10.1353/etc.2019.0004

Flores, M. M., & Milton, J. H. (2020). Teaching the partial products algorithm using the concrete-representational-abstract sequence. *Exceptionality.* Advance online publication. https://doi.org/10.1080/09362835.2020.1772070

Flores, M. M., Moore, A. J., & Meyer, J. M. (2020). Teaching the partial products algorithm with the concrete representational abstract sequence and the strategic instruction model. *Psychology in the Schools*, *57*(6), 946–958. https://doi.org/10.1002/pits.22335

Fonger, N. L. (2019). Meaningfulness in representational fluency: An analytic lens for students' creations, interpretations, and connections. *The Journal of Mathematical Behavior*, *54.* https://doi.org/10.1016/j.jmathb.2018.10.003

Fonger, N. L., & Altindis, N. (2019). Meaningful mathematics: Networking theories on multiple representations and quantitative reasoning. *North American Chapter of the International Group for the Psychology of Mathematics Education*.

Friesen, M. E., & Kuntze, S. (2020). The role of professional knowledge for teachers' analysing of classroom situations regarding the use of multiple representations. *Research in Mathematics Education*, *22*(2), 117–134. https://doi.org/10.1080/14794802.2019.1710555

Gallagher, K., & Infante, N. E. (2021). A case study of undergraduates' proving behaviors and uses of visual representations in identification of key ideas in topology. *International Journal of Research in Undergraduate Mathematics Education*(8), 176–210. https://doi.org/10.1007/s40753-021-00149-6

Gómez-Arciga, A., Olvera-Martínez, C., Aguilar-Magallón, D. A., & Fernández, W. E. P. (2018). Digital reasoning: Representing, exploring and solving word problems through the use of GeoGebra. *North American Chapter of the International Group for the Psychology of Mathematics Education*.

Gulkilik, H. (2021). Representational fluency in calculating volume: An investigation of students' conceptions of the definite integral. *International Journal of Mathematical Education in Science and Technology*, 1–23. https://doi.org/10.1080/0020739X.2021.1958943

Gulkilik, H., Moyer-Packenham, P. S., Ugurlu, H. H., & Yuruk, N. (2020). Characterizing the growth of one student's mathematical understanding in a multi-representational learning environment. *The Journal of Mathematical Behavior*, *58.* https://doi.org/10.1016/j.jmathb.2020.100756

Gulz, A., Londos, L., & Haake, M. (2020). Preschoolers' understanding of a teachable agent-based game in early mathematics as reflected in their gaze behaviors - An experimental study. *International Journal of Artificial Intelligence in Education*, *30*(1), 38–73.

Guncaga, J., & Zilkova, K. (2019). Visualisation as a method for the development of the term rectangle for pupils in primary school. *European Journal of Contemporary Education*, *8*(1), 52–68. https://doi.org/10.13187/ejced.2019.1.52

Haj-Yahya, A. (2020). Do prototypical constructions and self-attributes of presented drawings affect the construction and validation of proofs? *Mathematics Education Research Journal*, *32*(4), 685–718. https://doi.org/10.1007/s13394-019-00276-z

Haj-Yahya, A. (2021). Can a number of diagrams linked to a proof task in 3D geometry improve proving ability? *Mathematics Education Research Journal.* Advance online publication. https://doi.org/10.1007/s13394-021-00385-8

Hollebrands, K., & Okumuş, S. (2018). Secondary mathematics teachers' instrumental integration in technology-rich geometry classrooms. *Journal of Mathematical Behavior*, *49*, 82–94. https://doi.org/10.1016/j.jmathb.2017.10.003

Hoogland, K., Pepin, B., Koning, J. de, Bakker, A., & Gravemeijer, K. (2018). Word problems versus image-rich problems: An analysis of effects of task characteristics on students' performance on contextual mathematics problems. *Research in Mathematics Education*, *20*(1), 37–52. https://doi.org/10.1080/14794802.2017.1413414

Jemutai, S., & Webb, P. (2019). Effects of a 6 Brick Duplo Block guided pay intervention on pre-literate learners' visual perception. *South African Journal of Childhood Education*, *9*(1). https://doi.org/10.4102/sajce.v9i1.634

Johnson, H. L., Gardner, A., Smith, A., Olson, G., & Wang, X. (2019). Interacting with dynamic computer activities impacts college algebra students' math attitudes and performance. *North American Chapter of the International Group for the Psychology of Mathematics Education*.

Jones, SR (2018). Prototype images in mathematics education: The case of the graphical representation of the definite integral. *Educational Studies in Mathematics*, *97*(3), 215–234. https://doi.org/10.1007/s10649-017-9794-z

Jones, S. R. (2020). Scalar and vector line integrals: A conceptual analysis and an initial investigation of student understanding. *Journal of Mathematical Behavior*, *59.* https://doi.org/10.1016/j.jmathb.2020.100801

Kaminski, J. A., & Sloutsky, V. M. (2020). The use and effectiveness of colorful, contextualized, student-made material for elementary mathematics instruction. *International Journal of STEM Education*, *7*.

KarimiFardinpour, Y., & Gooya, Z. (2018). Comparing three methods of geometrical approach in visualizing differential equations. *International Journal of Research in Undergraduate Mathematics Education*, *4*(2), 286–304. https://doi.org/10.1007/s40753-017-0061-6

Kaur, B. (2019). The why, what and how of the 'Model' method: A tool for representing and visualising relationships when solving whole number arithmetic word problems. *ZDM – Mathematics Education*, *51*(1), 151–168. https://doi.org/10.1007/s11858-018-1000-y

Ke, F. (2019). Mathematical problem solving and learning in an architecture-themed epistemic game. *Educational Technology Research and Development*, *67*(5), 1085–1104.

Ke, F., & M. Clark, K. (2020). Game-based multimodal representations and mathematical problem solving. *International Journal of Science and Mathematics Education*, *18*(1), 103–122.

Kobiela, M., & Lehrer, R. (2019). Supporting dynamic conceptions of area and its measure. *Mathematical Thinking and Learning*, *21*(3), 178–206. https://doi.org/10.1080/10986065.2019.1576000

Kohen, Z., Amram, M., Dagan, M., & Miranda, T. (2019). Self-efficacy and problem-solving skills in mathematics: The effect of instruction-based dynamic versus static visualization. *Interactive*

Learning Environments. Advance online publication. https://doi.org/10.1080/10494820.2019.1683588

Kop, Peter M. G. M., Janssen, Fred J. J. M., Drijvers, P. H. M., & van Driel, J. H. (2021). Promoting insight into algebraic formulas through graphing by hand. *Mathematical Thinking and Learning*, *23*(2), 125–144. https://doi.org/10.1080/10986065.2020.1765078

Kosko, K. W. (2020). The multiplicative meaning conveyed by visual representations. *The Journal of Mathematical Behavior*, *60.* https://doi.org/10.1016/j.jmathb.2020.100800

Krawitz, J., & Schukajlow, S. (2020). When can making a drawing hinder problem solving? Effect of the drawing strategy on linear overgeneralizations and problem solving. *Frontiers in Psychology*, *11.* https://doi.org/10.3389/fpsyg.2020.00506

Lee, C.‐Y., Lei, K. H., Chen, M.‐J., Tso, T.‐Y., & Chen, I.‐P. (2018). Enhancing understanding through the use of structured representations. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(5), 1875–1886. https://doi.org/10.29333/ejmste/85424

Lee, H. Y [H. Y.], Moore, K. C., & Tasova, H. I. (2019). Reasoning within quantitative frames of reference: The case of Lydia. *Journal of Mathematical Behavior*, *53*, 81–95. https://doi.org/10.1016/j.jmathb.2018.06.001

Lee, S., & Ke, F. (2019). The format of problem representation for in-game learning supports. *Journal of Computer Assisted Learning*, *35*(3), 390–406. https://doi.org/10.1111/jcal.12345

Lee, S., Ke, F., & Ryu, J. (2020). Engagement and effectiveness of symbolic and iconic learning support for math problem representation: An eye tracking study. *Interactive Learning Environments.* Advance online publication. https://doi.org/10.1080/10494820.2020.1848877

Lepak, J. R., Wernet, J. L., & Ayieko, R. A. (2018). Capturing and characterizing students' strategic algebraic reasoning through cognitively demanding tasks with focus on representations. *The Journal of Mathematical Behavior*, *50*, 57–73. https://doi.org/10.1016/j.jmathb.2018.01.003

Liang, C.‐P., & She, H.‐C. (2021). Investigate the effectiveness of single and multiple representational scaffolds on mathematics problem solving: Evidence from eye movements. *Interactive Learning Environments.* Advance online publication. https://doi.org/10.1080/10494820.2021.1943692

Lowrie, T., Logan, T., & Hegarty, M. (2019). The influence of spatial visualization training on students' spatial reasoning and mathematics performance. *Journal of Cognition and Development*, *20*(5), 729–751. https://doi.org/10.1080/15248372.2019.1653298

Ludewig, U., Lambert, K., Dackermann, T., Scheiter, K., & Möller, K. (2020). Influences of basic numerical abilities on graph reading performance. *Psychological Research*, *84*(5), 1198–1210. https://doi.org/10.1007/s00426-019-01144-y

Luz, Y., & Yerushalmy, M. (2019). Students' conceptions through the lens of a dynamic online geometry assessment platform. *Journal of Mathematical Behavior*, *54.* https://doi.org/10.1016/j.jmathb.2018.12.001

Marmur, O., Yan, X. H., & Zazkis, R. (2020). Fraction images: The case of six and a half. *Research in Mathematics Education*, *22*(1), 22–47. https://doi.org/10.1080/14794802.2019.1627239

Martínez-Planell, R., & Trigueros, M. (2019). Using cycles of research in APOS: The case of functions of two variables. *Journal of Mathematical Behavior*, *55.* https://doi.org/10.1016/j.jmathb.2019.01.003

Martínez-Planell, R., & Trigueros, M. (2020). Students' understanding of Riemann sums for integrals of functions of two variables. *Journal of Mathematical Behavior*, *59.* https://doi.org/10.1016/j.jmathb.2020.100791

Martinovic, D., & Manizade, A. G. (2020). Teachers using GeoGebra to visualize and verify conjectures about trapezoids. *Canadian Journal of Science, Mathematics and Technology Education*, *20*(3), 485–503. https://doi.org/10.1007/s42330-020-00103-9

Mavani, D., Mavani, B., & Schafer, M. (2018). A case study of two selected teachers as they integrated dynamic geometry software as a visualisation tool in teaching geometry. *African Journal of Research in Mathematics, Science and Technology Education*, *22*(3), 297–307. https://doi.org/10.1080/18117295.2018.1522716

McGowen, M. A., & Davis, G. E. (2019). Spectral analysis of concept maps of high and low gain undergraduate mathematics students. *Journal of Mathematical Behavior*, *55.* https://doi.org/10.1016/j.jmathb.2019.01.002

Meier, A., Hannula, M., & Toivanen, M. (2018). Mathematics and outdoor photography experience - Exploration of an approach to mathematical education, based on the theory of Dewey's aesthetics. *International Journal on Math, Science and Technology Education*, *6*(2), 146–166.

Mejia-Ramos, J. P., & Weber, K. (2019). Mathematics majors' diagram usage when writing proofs in calculus. *Journal for Research in Mathematics Education*, *50*(5), 478–488. https://doi.org/10.5951/jresematheduc.50.5.0478

Mithalal, J., & Balacheff, N. (2019). The instrumental deconstruction as a link between drawing and geometrical figure. *Educational Studies in Mathematics*, *100*(2), 161–176. https://doi.org/10.1007/s10649-018-9862-z

Mkhatshwa, T. P. (2020). Calculus students' quantitative reasoning in the context of solving related rates of change problems. *Mathematical Thinking and Learning*, *22*(2), 139–161. https://doi.org/10.1080/10986065.2019.1658055

Montenegro, P., Costa, C., & Lopes, B. (2018). Transformations in the visual representation of a figural pattern. *Mathematical Thinking and Learning*, *20*(2), 91–107. https://doi.org/10.1080/10986065.2018.1441599

Morano, S [S.], & Riccomini, P. J. (2020). Demonstrating conceptual understanding of fraction arithmetic: An analysis of pre-service special and general educators' visual representations. *Teacher Education and Special Education*, *43*(4), 314–331. https://doi.org/10.1177/0888406419880540

Morano, S [Stephanie], Flores, M. M., Hinton, V., & Meyer, J. (2020). A comparison of concrete-representational-abstract and concrete-representational-abstract-integrated fraction interventions for students with disabilities. *Exceptionality*, *28*(2), 77–91. https://doi.org/10.1080/09362835.2020.1727328

Moyer-Packenham, P. S., Roxburgh, A. L., Litster, K., & Kozlowski, J. S. (2022). Relationships between semiotic representational transformations and performance outcomes in digital math games. *Technology, Knowledge and Learning: Learning Mathematics, Science and the Arts in the Context of Digital Technologies*, *27*(1), 223–253. https://doi.org/10.1007/s10758-021-09506-5

Okumus, S., & Hollebrands, K. (2019). Middle school students' employments of gestures for forming three-dimensional objects using an extrusion or spinning method. *Journal of Mathematical Behavior*, *56.* https://doi.org/10.1016/j.jmathb.2019.100737

Ott, B. (2020). Learner-generated graphic representations for word problems: An intervention and evaluation study in grade 3. *Educational Studies in Mathematics*, *105*(1), 91–113. https://doi.org/10.1007/s10649-020-09978-9

Övez, F. T. D., & Akar, N. (2018). Anthropological analysis of content knowledge of preservice elementary mathematics teachers' on graphs. *Educational Research and Reviews*, *13*(8), 281–306.

Ozaltun-Celik, A. (2021). A calculus student's understanding of graphical approach to the derivative through quantitative reasoning. *International Journal on Math, Science and Technology Education*, *9*(1), 892–916.

Palatnik, A., & Dreyfus, T. (2019). Students' reasons for introducing auxiliary lines in proving situations. *Journal of Mathematical Behavior*, *55.* https://doi.org/10.1016/j.jmathb.2018.10.004

Paoletti, T., Lee, H. Y [Hwa Young], Rahman, Z., Vishnubhotla, M., & Basu, D. (2020). Comparing graphical representations in mathematics, science, and engineering textbooks and practitioner journals. *International Journal of Mathematical Education in Science and Technology*, 1–20. https://doi.org/10.1080/0020739X.2020.1847336

Parr, E. D. (2021). Undergraduate students' interpretations of expressions from calculus statements within the graphical register. *Mathematical Thinking and Learning.* Advance online publication. https://doi.org/10.1080/10986065.2021.1943608

Patahuddin, S. M [S. M.], Rokhmah, S., & Ramful, A [A.] (2020). What does teaching of spatial visualisation skills incur: An exploration through the visualise-predict-check heuristic. *Mathematics Education Research Journal*, *32*(2), 307–329. https://doi.org/10.1007/s13394-020-00321-2

Patahuddin, S. M [Sitti Maesuri], Usman, H. B., & Ramful, A [Ajay] (2018). Affordances from number lines in fractions instruction: Students' interpretation of teacher's intentions. *International Journal of Science and Mathematics Education*, *16*(5), 909–928.

Patterson, C. L., & McGraw, R. (2018). When time is an implicit variable: An investigation of students' ways of understanding graphing tasks. *Mathematical Thinking and Learning*, *20*(4), 295–323. https://doi.org/10.1080/10986065.2018.1509421

Relaford-Doyle, J., & Nunez, R. (2021). Characterizing students' conceptual difficulties with mathematical induction using visual proofs. *International Journal of Research in Undergraduate Mathematics Education*, *7*(1), 1–20. https://doi.org/10.1007/s40753-020-00119-4

Rellensmann, J., Schukajlow, S., Blomberg, J., & Leopold, C. (2021). Does strategic knowledge matter? Effects of strategic knowledge about drawing on students' modeling competencies in the domain of geometry. *Mathematical Thinking and Learning.* Advance online publication. https://doi.org/10.1080/10986065.2021.2012741

Rellensmann, J., Schukajlow, S., Blomberg, J., & Leopold, C. (2022). Effects of drawing instructions and strategic knowledge on mathematical modeling performance: Mediated by the use of the drawing strategy. *Applied Cognitive Psychology*, acp.3930. https://doi.org/10.1002/acp.3930

Rellensmann, J., Schukajlow, S., & Leopold, C. (2020). Measuring and investigating strategic knowledge about drawing to solve geometry modelling problems. *ZDM – Mathematics Education*, *52*(1), 97–110. https://doi.org/10.1007/s11858-019-01085-1

Root, J. R., Cox, S. K., & Gonzalez, S. (2019). Using modified schema-based instruction with technology-based supports to teach data analysis. *Research and Practice for Persons with Severe Disabilities*, *44*(1), 53–68.

Rosenblum, L. P., Cheng, L., & Beal, C. R. (2018). Teachers of students with visual impairments share experiences and advice for supporting students in understanding graphics. *Journal of Visual Impairment & Blindness*, *112*(5), 475–487.

Rosenblum, L. P., Cheng, L., Zebehazy, K., Emerson, R. W., & Beal, C. R. (2020). Teachers' descriptions of mathematics graphics for students with visual impairments: A preliminary investigation. *Journal of Visual Impairment & Blindness*, *114*(3), 231–236. https://doi.org/10.1177/0145482X20923442

Schoevers, E. M., Leseman, P. P., & Kroesbergen, E. H. (2020). Enriching mathematics education with visual arts: Effects on elementary school students' ability in geometry and visual arts. *International Journal of Science and Mathematics Education*, *18*(8), 1613–1634. https://doi.org/10.1007/s10763-019-10018-z

Schukajlow, S., Blomberg, J., Rellensmann, J., & Leopold, C. (2021). Do emotions and prior performance facilitate the use of the learner-generated drawing strategy? Effects of enjoyment, anxiety, and intramathematical performance on the use of the drawing strategy and modelling performance. *Contemporary Educational Psychology*, *65.* https://doi.org/10.1016/j.cedpsych.2021.101967

Schukajlow, S., Blomberg, J., Rellensmann, J., & Leopold, C. (2021). The role of strategy-based motivation in mathematical problem solving: The case of learner-generated drawings. *Learning and Instruction.* Advance online publication. https://doi.org/10.1016/j.learninstruc.2021.101561

Shongwe, B. A causal-comparative study of South African pre-service primary mathematics teachers' spatial visualization ability: Does common content knowledge matter? *International Journal of Mathematical Education in Science and Technology.* Advance online publication. https://doi.org/10.1080/0020739X.2020.1869333

Smith, C., & Cekiso, M. (2020). Teachers' understanding and use of visual tools in their numeracy classrooms: A case study of two primary schools in Gauteng. *South African Journal of Childhood Education*, *10*(1), 1–8. https://doi.org/10.4102/sajce.v10i1.887

Soni, M., & Okamoto, Y. (2020). Improving children's fraction understanding through the use of number lines. *Mathematical Thinking and Learning*, *22*(3), 233–243. https://doi.org/10.1080/10986065.2020.1709254

Sunzuma, G., Chando, C., Gwizangwe, I., Zezekwa, N., & Zinyeka, G. (2020). In-service Zimbabwean teachers' views on the utility value of diagrams in the teaching and learning of geometry. *International Journal on Math, Science and Technology Education*, *8*(1), 1–18. https://doi.org/10.31129/LUMAT.8.1.1316

Swidan, O., & Naftaliev, E. (2019). The role of the design of interactive diagrams in teaching-learning the indefinite integral concept. *International Journal of Mathematical Education in Science and Technology*, *50*(3), 464–485. https://doi.org/10.1080/0020739X.2018.1522674

Takeuchi, M. A., & Liu, S. (2021). 'I am more of a visual learner': The disciplinary values and identities in school mathematics learning and group work. *The Journal of Mathematical Behavior*, *61.* https://doi.org/10.1016/j.jmathb.2020.100835

Tikhomirova, T., Kuzmina, Y., Lysenkova, I., & Malykh, S. (2019). The relationship between non-symbolic and symbolic numerosity representations in elementary school: The role of intelligence. *Frontiers in Psychology*, *10.* https://doi.org/10.3389/fpsyg.2019.02724

Tillema, E. S. (2018). An investigation of 6th graders' solutions of Cartesian product problems and representation of these problems using arrays. *The Journal of Mathematical Behavior*, *52*, 1–20. https://doi.org/10.1016/j.jmathb.2018.03.009

Usta, N., Yilmaz, M., Kartopu, S., & Kadan, Ö. F. (2018). Impact of visuals on primary school 4th graders' problem-solving success. *Universal Journal of Educational Research*, *6*(10), 2160–2168.

Vagova, R., Kmetova, M., & Lavicza, Z. (2020). Visual mental images' connected paper-and-pencil iconic and non-iconic representations. *International Journal for Technology in Mathematics Education*, *27*(1), 41–47. https://doi.org/10.1564/tme_v27.1.06

van Garderen, D., Scheuermann, A., Poch, A., & Murray, M. M. (2018). Visual representation in mathematics: Special education teachers' knowledge and emphasis for instruction. *Teacher Education and Special Education*, *41*(1), 7–23. https://doi.org/10.1177/0888406416665448

van Garderen, D., Scheuermann, A., & Poch, A. L. (2019). Special education teachers' perceptions of students' with disabilities ability, instructional needs, and difficulties using visual representations to solve mathematics problems. *Teacher Education and Special Education*, *42*(2), 175–188. https://doi.org/10.1177/0888406418793929

van Garderen, D., Scheuermann, A., Sadler, K., Hopkins, S., & Hirt, S. M. (2021). Preparing pre-service teachers to use visual representations as strategy to solve mathematics problems: What did they learn? *Teacher Education and Special Education*, *44*(4), 319–339. https://doi.org/10.1177/0888406421996070

van Rinsveld, A., Hornung, C., & Fayol, M. (2020). Finger Rapid Automatized Naming (RAN) predicts the development of numerical representations better than finger gnosis. *Cognitive Development*, *53.* https://doi.org/10.1016/j.cogdev.2019.100842

Venter, C. (2020). Learning the function concept by exploring digital images as functions. *Pythagoras*, *41*(1). https://doi.org/10.4102/pythagoras.v41i1.524

Vos, P., & Frejd, P. (2020). The object-tool duality in mathematical modelling. A framework to analyze students' appropriation of Sankey diagrams to model dynamic processes. *Avances De Investigacion En Educacion Matematica*(17), 52–66.

Wessman-Enzinger, N. M. (2019). Grade 5 children's drawings for integer addition and subtraction open number sentences. *The Journal of Mathematical Behavior*, *53*, 105–128. https://doi.org/10.1016/j.jmathb.2018.03.010

Widder, M., Berman, A., & Koichu, B. (2019). An a priori measure of visual difficulty of 2-D sketches depicting 3-D objects. *Journal for Research in Mathematics Education*, *50*(5), 489–528. https://doi.org/10.5951/jresematheduc.50.5.0489

Wilkie, K. J. (2019). Investigating secondary students' generalization, graphing, and construction of figural patterns for making sense of quadratic functions. *Journal of Mathematical Behavior*, *54.* https://doi.org/10.1016/j.jmathb.2019.01.005

Wilkie, K. J. (2022). Generalization of quadratic figural patterns: Shifts in student noticing. *Journal of Mathematical Behavior*, *65.* https://doi.org/10.1016/j.jmathb.2021.100917

Yilmaz, A., Akyuz, D., & Stephan, M. (2019). Middle grade students' evoked concept images of number line models and their calculation strategies with integers using these models. *International Journal of Education in Mathematics, Science and Technology*, *7*(1), 93–115. https://doi.org/10.18404/ijemst.509292

Yilmaz, R., & Argun, Z. (2018). Role of visualization in mathematical abstraction: The case of congruence concept. *International Journal of Education in Mathematics, Science and Technology*, *6*(1), 41–57. https://doi.org/10.18404/ijemst.328337

Yorde, S., & McCollum, J. A. (2018). A workable problem: Constructing a 3-D puzzle with young children with disabilities. *Journal of Research in Childhood Education*, *32*(3), 326–342.

Zakirova, V. G., Zelenina, N. A., Smirnova, L. M., & Kalugina, O. A. (2019). Methodology of teaching graphic methods for solving problems with parameters as a means to achieve high mathematics learning outcomes at school. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(9), 1–12. https://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2020-52967-002&lang=de&site=ehost-live