‘Specialization in ICTs and Special Education: Psychopedagogy of Integration’ Postgraduate Program
DEMOCRITUS UNIVERSITY OF THRACE Department of Greek Philology in collaboration with
NCSR DEMOKRITOS Informatics and Telecommunications Institute

RASCH ANALYSIS AND IMPLICATION OF SPATIAL REASONING INSTRUMENT OF RAMFUL, LOWRIE AND LOGAN IN PRIMARY STUDENTS 9-13 YEARS OLD TO PREVENT LEARNING DIFFICULTIES IN MATHEMATICS

PITSIKOGLOU STYLIANI

POSTGRADUATE
THESIS

Athens
2020

ABSTRACT

In recent years, spatial thinking is being seen as an important element of programs in Science-Technology-Engineering-Mathematics (STEM). In the literature, spatial thinking is described as a developmental skill, highly correlated with gender and socio-economy status. Many instruments have been constructed so far in order to investigate a particular component of spatial thinking. These instruments have mainly focused on adults. In the current study, we perceive spatial thinking as comprising of mental rotation, spatial orientation and spatial visualization and we investigate the performance of 117 children 9-13 years old in the municipality of "Peristeri" in the basin of Athens, in order to preventing the Learning Difficulties in Mathematics. The instrument was a Greek translation of the "Spatial Thinking Instrument" (SRI). At the stage of data analysis we examined factors as gender, age, pleurisy and minutes of completing. We also examined the efficiency of the above research tool according to the model Rasch analysis. We have found that the correlation between the spatial ability and either gender, age, and pleurisy in not statistically significant. On the contrary, testing time correlates significantly with spatial thinking. We have however found that a large number of items in the aforementioned instrument must be rede- signed in order to represent the spatial ability of Greek primary students.

Key words: *spatial thinking, mental rotation, spatial orientation, spatial visualization, mathematics achievement, Learning Difficulties in Mathematics, model Rasch analysis*

References

Assel, M. A., Landry, S. H., Swank, P., Smith, K. E., & Steelman, L. M. (2003). Precursors to mathematical skills: examining the roles of visual-spatial skills, executive processes, and parenting factors. Applied Developmental Science, 7(1), σσ. 27-38.

Abad, C. (2018). The development of early spatial thinking. FIU electronic theses and dissertations. Ανάκτηση από http://digitalcommons.fiu.edu/etd/3574

Altıner, Ç. E., & Doğan, M. (2018). Investigating the spatial reasoning skills of student in the context of mathematical thinking profiles. European Journal Of Education Studies, 4(11), σσ. 26-38.

Babbie, E. (2011). Εισαγωγή στην κοινωνική έρευνα. (Κ. Ζαφειρόπουλος, Επιμ., & Γ. Βογιατζής, Μεταφρ.) Αθήνα: Εκδόσεις Κριτική.

Bednarz, R., & Lee, J. (2018). The components of spatial thinking: empirical evidence. Boletim Paulista de Geografia, 99, σσ. 161-168.

Bullens, J., Nardini, M., Doeller, C. F., Braddick, O., Postma, A., & Burgess, N. (2010). The role of landmarks and boundaries in the development of spatial memory. Developmental Science, 13(1), σσ. 170-180.

Casey, B. M., Dearing, E., Dulaney, A., Heyman, M., & Springer, R. (2014). Young girls' spatial and arithmetic performance: The mediating roleof maternal supportive interactions during joint spatial problem solving. Early Childhood Research Quarterly, 29, σσ. 636-648.

Casey, B., & Bobb, B. (2003, October). The power of block building. Teaching Children Mathematics, 10(2), σσ. 98-103.

Charcharos, C., Kokla, M., & Tomai, E. (2015). Assesing spatial thinking ability. GEOTHNK International Closing Conference, (σσ. 151-166). Pallini.

Cheng, Y.-L., & Mix, K. S. (2014). Spatial training improves children's mathematics ability. Journal of Cognition and Development, 15(1), σσ. 2-11.

Chu, M., & Kita, S. (2008). Spontaneous gestures during mental rotation tasks: Insights into the microdevelopment of the motor strategy. *Journal of Experimental Psychology: General, 137*(4).

Cohen, L., Manion, L., & Morrison, K. (2007). *Μεθοδολογία εκπαιδευτικής έρευνας.* (Σ. Κυρανάκης, Μ. Μαυράκη, Χ. Μητσοπούλου, Π. Μπιθάρα, & Μ. Φιλοπούλου, Μεταφρ.) Αθήνα: Εκδόσεις Μεταίχμιο.

Colombo, D., Serino, S., Tuena, C., Pedroli, E., Dakanalis, A., Cipresso, P., & Riva, G. (2017). Egocentric and allocentric spatial reference frames in aging: a systematic review. *Neuroscience and Biobehavioral Reviews, 80*, σσ. 605-621.

diSessa, A. A. (2004). Metarepresentation: native competence and targets for instruction. *Cognition and instruction, 22*(3), σσ. 293-331.

Drigas, A., & Pappas, M. A. (2017). The consciousness-intelligence-knowledge pyramid: an 8x8 layer model. *International Journal of Recent Contributions from Engineering, Science & IT (iJES), 5*(3), σσ. 14-25.

European Commission. (2012). *EU high level group of experts on literacy (Final Report).* Luxembourg: Publications Office of the European Union.

Ferrando, P., & Lorenzo-Seva, U. (2017). Program FACTOR at 10: Origins, development and future directions. *Psicothema, 29*(2), σσ. 236-240.

Fiantika, F. R. (2017). Representation elements of spatial thinking. *The 3rd International Conference on Mathematics, Science and Education.* IOP Publishing.

Gagnier, K., & Fisher, K. (2017). *Spatial thinking: a missing building block in STEM education.* Johns Hopkins: Science of Learning Institute.

Geiser, C., Lehmann, W., & Eid, M. (2008). A note on sex differences in mental rotation in different age groups. *Intelligence, 36*, σσ. 556-563.

Gersmehl, P. J., & Gersmehl, C. A. (2007). Spatial thinking by young children: neurologic evidence for early development and "educability". *Journal of Geography, 106*, σσ. 181-191.

Gersmehl, P. J., & Gersmehl, C. A. (2011). Spatial thinking: Where pedagogy meets neuroscience. *Problems of Education in the 21st Century, 27*, σσ. 48-66.

Gilligan, K. A., Flouri, E., & Farran, E. K. (2017). The contribution of spatial ability to mathematics achievement in middle childhood. *Journal of Experimental Child Psychology, 163*, σσ. 107-125.

Golledge, R., Marsh, M., & Battersby, S. (2008, March). Matching geospatial concepts with geographic educational needs. *Geographical Research, 46*(1), σσ. 85-98.

Gunderson, E. A., Raminez, G., Beilock, S. L., & Levine, S. C. (2012). The relation between spatial skill and early number knowledge: The role of the linear number line. *Developmental Psychology, 48*(5), σσ. 1229-1241.

Hegarty, M. (2010). Components of spatial intelligence. Στο J. P. Mestre, & B. H. Ross, *Psychology of Learning and Motivation: Congition in Education* (Τόμ. 55, σσ. 265-297). Academic Press. doi:https://doi.org/10.1016/S0079-7421(10)52007-3

Hegarty, M., & Tarampi, M. R. (2015). Teaching spatial thinking: perspectives from cognitive psychology. Στο *TSTIP@ COSIT* (σσ. 36-44).

Jo, I., & Bednarz, S. (2009). Evaluating geography textbook questions from a spatial perspective: using concepts of space, tools of representation, and cognitive processes to evaluate spatiality. *Journal of Geography, 108*(1), σσ. 4-13.

Kefalis, C., Kontostavlou, E., & Drigas, A. (2020). The effects of video games in memory and attention. *International Journal of Engineering Pedagogy (iJEP), 10*(1), σσ. 51-61.

Lee, J., & Bednarz, R. (2011). Components of spatial thinking: evidence from a spatial thinking ability test. *Journal of Geography, 111*(1), σσ. 15-26.

Linacre, J. M. (2020). *A user's guide to Minsteps ministep: Rasch- Model computer programs program manual 4.5.3.* Ανάκτηση Απρίλιος 15, 2020, από https://www.winsteps.com/a/Winsteps-Manual.pdf

Linn, M. C., & Petersen, A. C. (1985, December). Emergence and characterization of sex differences in spatial ability: a meta-analysis. *Child Development, 56*(6), σσ. 1479-1498.

Metoyer, S. K., Bednarz, S. W., & Bednarz, R. S. (2015). Spatial thinking in education: concepts, development, and assessment. Στο O. M. Solari, A. Demirci, & J. van der Schee (Επιμ.), *Geospatial Technologies and Geography Education in a Changing World* (σσ. 21-33). Tokyo: Springer.

National Research Council. (2006). *Learning to think spatially: GIS as a support system in the K-12 curriculum.* Washington: DC: The National Academies Press.

Newcombe, N. (2010). Increasing math and science learning by improving spatial thinking. *American Educator*, σσ. 29-43.

Newcombe, N. S. (2000). So, at last we can begin. *Developmental Science, 3*(3), σσ. 276-278.

Newcombe, N. S., & Frick, A. (2010). Early education for spatial intelligence: why, what, and how. *Mind, Brain and Education, 4*(3), σσ. 102-111.

Newcombe, N. S., & Huttenlocker, J. (2003). *Making space: the development of spatial representation and reasoning.* MIT Press.

Newcombe, N. S., & Shipley, T. F. (2015). Thinking about spatial thinking: new typology, new assessments. Στο J. S. Gero, *Studying Visual and Spatial Reasoning for Design Creativity* (σσ. 179-192). Springer.

Örnkloo, H., & von Hofsten, C. (2007). Fitting objects into holes: on the development of spatial cognition skills. *Developmental Psychology, 43*(2), σσ. 404-416.3

Passolunghi, M. C., & Mammarella, I. C. (2012). Selective Spatial Working Memory Impairment in a Group of Children With Mathematics Learning Disabilities and Poor Problem-Solving Skills. *Journal of Learning Disabilities, 45*(4), σσ. 341-350.

Quaiser-Pohl, C. (2003). The mental cutting test "schnitte" and the picture rotation test-two new measures to assess spatial ability. *International Journal of Testing, 3*(3), σσ. 219-231.

Quaiser-Pohl, C., Geiser, C., & Lehmann, W. (2006). The relationship between computer-game preference, gender, and mental-rotation ability. *Personality and Individual Differences, 40*, σσ. 609-619.

Quinn, P. C., & Liben, L. S. (2008). A sex difference in mental rotation in young infants. *Psychological Science, 19*(1), σσ. 1067-1070.

Quinn, P. C., Doran, M. M., & Papafragou, A. (2011). Does changing the reference frame affect infant categorization of the spatial relation BETWEEN? *Journal of Experimental Child Psychology, 109*, σσ. 109-122.

Ramful, A., Lowrie, T., & Logan, T. (2017). Measurement of spatial ability construction and validation of the spatial reasoning instrument for middle school students. *Journal of Psychoeducational Assessment, 35*(7), σσ. 709-727.

Robson, C. (2007). *Η έρευνα του πραγματικού κόσμου: ένα μέσον για κοινωνικούς επιστήμονες και επαγγελματίες ερευνητές.* (Κ. Μιχαλοπούλου, Επιμ., Β. Νταλάκου, & Κ. Βασιλικού, Μεταφρ.) Αθήνα: Εκδόσεις Gutenberg.

Robson, S. (2012). Knowing about the world: the development of children's concepts. Στο *Developing Thinking and Understanding in Young Children: An Introduction for Students.* London: Routledge.

Sorby, S. A. (1999). Developing 3-D spatial visualization skills. *Engineering Design Graphics Journal, 63*(2), σσ. 21-32.

Sorby, S., Veurink, N., & Streiner, S. (2018). Does spatial skills instruction improve STEM outcomes? The answer is 'yes'. *Learning and Individual Differences, 67*, σσ. 209-222.

Stieff, M., & Raje, S. (2010). Expert algorithmic and imagistic problem solving strategies in advanced chemistry. *Spatial Cognition & Computation, 10*(1), pp. 53-81.

Stieff, M., Lira, M. E., & Scopelitis, S. A. (2016). Gesture supports spatial thinking in STEM. *Cognition and Instruction, 34*(2), σσ. 80-99.

Stull, A. T., Hegarty, M., Dixon, B., & Stieff, M. (2012). Representational translation with concrete models in organic chemistry. *Cognition and Instruction, 30*(4),

σσ. 404-434.

Swanson, L. H., & Jerman, O. (2006). Math disabilities: a selective meta-analysis of the literature. *Review of Educational Research, 76*(2), σσ. 249-274.

Tzuriel, D., & Egozi, G. (2010, September/October). Gender differences in spatial ability of young children: the effects of training and processing strategies. *Child Development, 81*(5), σσ. 1417-1430.

Uttal, D. H., Meadow, N. G., Tipton, E., Hand, L. L., Alden, A. R., Warren, C., & Newcombe, N. S. (2013). The malleability of spatial skills: a meta-analysis of training studies. *Psychological Bulletin, 139*(2), σσ. 352-402.

van Garderen, D. (2006). Spatial Visualization, Visual Imagery, and Mathematical Problem Solving of Students With Varying Abilities. *Journal of Learning Disabilities, 39*(6), σσ. 496-506.

Verdine, B. M., Golinkoff, R. M., Hirsh-Parek, K., Newcombe, N. S., Filipowicz, A. T., & Chang, A. (2014, May/June). Deconstructing building blocks: preschoolers' spatial assembly performance relates to early mathematical skills. *Child Development, 85*(3), σσ. 1062-1076.

Verdine, B. N., Irwin, C. M., Golinkoff, R., & Hirsh-Parek, K. (2014). Contributions of executive function and spatial skills to preschool mathematics achievement. *Journal of Experimental Child Psychology, 126*, σσ. 37-51.

Zwartjes, L., Lázaro, M., Donert, K., Sánchez, I., González, R., & Wołoszyńska-Wiśniewska, E. (2017). Literature review on spatial thinking. *GI Learner*.

Αγαλιώτης, Ι. (2011). *Διδασκαλία μαθηματικών στην ειδική αγωγή και εκπαίδευση: φύση και εκπαιδευτική διαχείριση των μαθηματικών δυσκολιών.* Αθήνα: Εκδόσεις Γρηγόρη.

Τσαούσης, Ι. (2008). Μετρώντας τη χωρο-αντιληπτική ικανότητα: Η ανάπτυξη και τα ψυχομετρικά χαρακτηριστικά του Τεστ Αντίληψης Χώρου (ΤΑΧ). *Ψυχολογία, 15*(4), σσ. 411-431.