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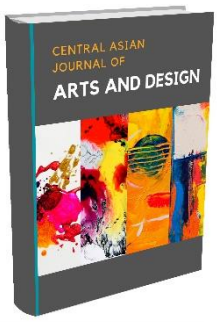

Analysis of the Work of Foreign Researchers on the Prevention of Typical Errors Made by Students

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Abstract
The article reviews the theoretical literature on the issue of the occurrence and causes of errors in learning, identifies the types of errors. The author analyzes studies on typical errors made by students when mastering geometric problems.

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Schleppenbach and others[*] investigated the use of errors in classroom discussion by comparing the lessons of Chinese and American teachers. They report that while American teachers tended to avoid and hide student mistakes, Chinese teachers tended to force students to think about the original question in conceptual ways. Indeed, repeating the procedure until students realize their mistakes is a well-known, typical strategy that US teachers have used when dealing with their students' mistakes in the classroom.[†] Ball emphasizes that teachers should go beyond the superficial "right or wrong" analysis of tasks. Rather, teachers should use student mistakes as a window into student understanding, aiming to help students understand the conceptual basis of their mistakes.[‡]

Students' mistakes in solving geometric problems are described using Newman's error analysis. The Newman procedure is a sequential step in understanding and analyzing when solving a problem. Students face various obstacles when answering tasks, namely, problems of reading, understanding,

[*]**Meg Schleppenbach and others,** 'Teachers' responses to student mistakes in Chinese and U.S. mathematics classrooms' (2007) 108(2) The Elementary School Journal131–147

[†]**Rossella Santagata,** 'Practices and beliefs in mistake-handling activities: A video study of Italian and US mathematics lesson' (2005) 21(5)Teaching and Teacher Education491–508

[‡]**Deborah Loewenberg Ball,** 'Prospective elementary and secondary teachers' understanding of division' (1990) 21 Journal forResearch in Mathematics Education132–144.

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transformation, processing and coding.[§] The identification of students' mistakes is required as a guideline when choosing suitable learning models and information technology tools, based on the spatial intelligence of students on geometric material. Students are not aware of the mistakes made. In addition, students do not know where the error occurred, so they cannot conduct a reflection to correct the mistakes made. Therefore, it is necessary to conduct a study to describe the mistakes of students in solving geometric problems from students' spatial intelligence perspective.[**] In this vein, spatial intelligence is measured using indicators, including the ability to determine the vertical and horizontal direction of an object (spatial perception), the ability to see the movement or displacement of part of the configuration (visualization), the ability to determine the results of two- and three-dimensional rotation (mental rotation), to associate the configuration of an object with another object (spatial relation) and the ability to guess the image of an object at a certain angle (spatial orientation).[††]

Research shows that one of the most common types of errors is the so-called "perception errors", which arise due to the fact that students do not have the ability to interpret questions and apply question processing strategies. With this error, the error most often occurs when choosing information, and it is difficult for students to distinguish between relevant and irrelevant information within the task.[‡‡] Another fairly common type of error is the "transformation error", which occurs when the student understands the essence of the problem, but cannot determine the sequence of operations necessary to solve the problem.[§§] There are also procedural errors that occur when a student can determine the sequence of operations necessary to solve a problem, but makes a mistake when applying the procedure.[***] And finally, an encoding error is the last type of error that needs to be identified. This error manifests itself in the last stage of solving a geometric problem, in which students incorrectly complete the final answer. For example, when students have to determine the surface area of a prism, with a known base length and height of the prism, they incorrectly indicate the final answer, making mistakes when calculating the final result.[†††]

In cases where a student made a mistake or came to the wrong answer, teachers' understanding of the basics of mistakes is necessary for the purposes of learning, which is related to the current understanding of students.[‡‡‡] Some may approach the interaction with the student around the wrong answer in order to help the student correct the mistake.[§§§] For example, Jacobs and Ambrose describe a set of deliberate actions to **support** a student's mathematical reasoning. On the contrary, others focused on **developing students' thinking**. As such, Megan Shaughnessy and others in their work discussed the skills and abilities of teachers to encourage students to think when a student has the wrong answer. In this case, if the student's thinking is sufficiently probed, the student is able to recognize the mistake

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[§] **Allan Leslie White,** 'Active Mathematics in Classrooms: Finding out why children make mistakes and thendoing something to help them' (2015) 15(4) Square One 15-19

[**] **N Riastutti, I Pramudya and M Mardiyana,** 'Students' Errors in Geometry Viewed from Spatial Intelligence (2017) 895(1)Journal of Physics Conference Series<10.1088/1742-6596/895/1/012029> accessed 27 January 2022.

[††] **Peter Herbert Maier,** 'Spatial Geometry and Spatial Ability-How to Make Solid Geometry Solid?' inElmar Cohors-Fresenborg and others (eds) *Selected Papersfrom The Annual Conference of Didactics of Mathematics*(Osnabrueck 1996).

[‡‡] **Ariyadi Wijaya and others**, 'Difficulties in solving context-based PISA mathematics tasks: An analysis ofstudents' errors' (2014) 11(3) The Mathematics Educator555-584

[§§] **M Clements,** 'Analysis Children's Errors on Written Mathematical Tasks EducationalStudies in Mathematics' (1980) 11(1) Educational Studies in Mathematics1-21.

[***] ibid 4.

[†††] ibid 4.

[‡‡‡] **Karin Brodie,** 'Learning about learner errors in professional learning communities' (2014) 85(2) Educational Studies in Mathematics 221–239.

[§§§] **Victoria R.Jacobs and Rebecca C.Ambrose,** 'Making the most of story problems' (2008) 15(5) Teaching Children Mathematics 260–266.

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and reconsider his/her work.[****]

Another study presents the results of an analysis of typical (common) differentiation errors made by electrical engineering students. Possible reasons that led to common mistakes and misconceptions among students when solving tasks were identified. The results showed that students often made mistakes when solving the main derivative formula. Some of them incorrectly differentiated functions, while others could not remember the derivative of the base function. Based on this, it was concluded that the errors could have been caused by their previous poor knowledge of the basics of mathematics and excessive focus on specific mathematical rules. Thus, this study revealed the causes of errors related to the quality of previous education or with their tendency to only memorize mathematical formulas;[††††] at the same time, it is not known what role external factors contribute to students making those mistakes, for example, gaps in educational materials or intentional traps in assignments.

Berger and Brodie argue that typical mistakes empower teachers, because such mistakes give them the opportunity to figure them out without blaming students and themselves."[‡‡‡‡] This approach also contributes to the creation of a favorable (positive) learning environment. Maria Tulis in her work notes that teachers should be sensitive to students' mistakes and should create a positive climate of mistakes, which is determined by the quality of everyday classroom experience in situations of mistakes. By "positive climate" she means a learning environment with a positive culture of mistakes, in which students are able to recognize their misconceptions and, consequently, initiate learning processes. On the contrary, a negative error management culture, which usually excludes communication and error correction, occurs when students suspect that their mistakes are evaluated negatively, or when students expect mistakes to be explained by a lack of skills.[§§§§]

Kornell and others conducted a study that directly compared the effect of creating and not having an error. They compared a condition in which the answer or goal was simply given to participants without intermediate error generation (no error condition) with a condition in which participants were asked to guess the answer first before giving the correct answer (error generation condition). The experiment was carefully controlled to ensure that the amount of time spent learning the correct answer was the same under different conditions. Kornell and his colleagues also excluded from consideration any cases when a person did not create an error in the error generation condition. The study revealed that in the final test, participants were significantly better at remembering correct answers when they made a mistake than when they didn't. Thus, it seems that error generation is not necessarily bad, and that it should be avoided at all costs. In reality, error generation seems to promote learning.[*****]

There is a broad consensus that it is important for teachers to be familiar with their students' ways of thinking about mathematical concepts, both right and wrong. The study of possible causes of common

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[****] **Meghan Shaughnessy and others,** 'I think I made a mistake: How do prospective teachers elicit the thinking of a student who has made a mistake?' (2021) 24 Journal of Mathematics Teacher Education335–359.

[††††] **ZarithSofiah Binti Othman, Ahmad Khudzairi Bin Khalidand Aishah Binti Mahat,** 'Students' Common Mistakes in Basic Differentiation Topics' (2018) 1974(1) AIP Conference Proceedings <https://doi.org/10.1063/1.5041709> accessed 05 February 2022.

[‡‡‡‡] **Margot Berger and Karin Brodie,** 'Toward a discursive framework for learner errors in mathematics'in VimolanMudaly (eds)*Proceedings of the eighteenth annual meeting of the Southern African Association for research in mathematics, science and technology education. Improving the quality of Science, Mathematics and Technology Education through relevant research and a continued multi- and inter-disciplinary approach to teaching* (University of Kwa-Zulu 2010).

[§§§§] **MariaTulis**, 'Error management behavior in classrooms: Teachers' responses to student mistakes' (2013) 33 Teaching and Teacher Education56-68.

[*****] **Nate Kornell, Matthew Jensen Hays and Robert A Bjork,** 'Unsuccessful retrieval attempts enhance subsequent learning' (2009) 35(4) J Exp Psychol Learn Mem Cogn. 989-98.

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(typical) mistakes and misconceptions of students can contribute to the expansion of knowledge and skills of teachers. The presence of typical errors can create an opportunity for the use of surveys and personal interviews with students to identify their general tendency of thinking (and) or external causes of errors, which, in turn, will play a positive role in improving the knowledge, tools and educational approaches of teachers, and possibly also for revising the whole learning system.[†††††]

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