Software-supported development of visuospatial abilities

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The poster and its background

Our proposed poster presents the software mathematikus.de which we designed to support the development of visuospatial abilities. The importance of these abilities is undisputed and well documented (e.g., Maier 1994). They play a crucial role in many aspects of thinking, and their targeted improvement seems possible (e.g., Gilligan, Thomas, & Farran 2019). However, traditional methods to promote visuospatial abilities are often limited. We discuss three obstacles that impede the development of visuospatial abilities in mathematics lessons and demonstrate how our software could be used to overcome such shortcomings. Students' ways of working with the software and their reasoning strategies are the subject of our research, which we will report later.

Five aspects of "visuospatial ability"

Visuospatial qualification is the ability of humans to perceive objects in their environment and mentally process these sensory impressions. We can create mental pictures of objects without regard for their actual existence and perform mental operations on them, such as mental rotation or spatial perspective-taking (cf. Maier 1994). This complex construct needs to be differentiated into multiple facets or aspects for which concrete tasks can be developed to enable efficient teaching. Since Thurstone's (cf. 1938) conceptualization of visuospatial abilities, there were numerous factor-analytic attempts to identify such composing factors (cf. Carroll 1993). Even though there is no clear consensus about the factor-analytical structure of visuospatial ability, for our purposes, we utilized the following five reappearing aspects to categorize exercises that are meant to foster these abilities: Spatial perception, spatial visualization, the imagination of rotation, the imagination of spatial relations, and spatial orientation.

Reasons for fostering visuospatial abilities

Acquiring visuospatial abilities is by no means merely useful for correctly answering a handful of scholastic geometry-related problems, but rather seems to be of fundamental value in a myriad of areas, including scientific thinking (cf. Castro-Alonso & Uttal, 2019). The ability to imagine numbers, numerical relations and operations is crucial for success in mathematics (cf. Georges, Cornu, & Schiltz 2019). Mental calculation can be seen as an imaginary motion along a number line.

Three obstacles in the development of visuospatial abilities

When fostering visuospatial abilities, e.g., in geometry lessons, *three obstacles* can be observed in praxis: The availability of training materials is usually limited and restricted to widespread solids without atypical variations (1). Often, commonly used exercises contain time-consuming secondary activities. For instance, students must draw, cut, and fold when verifying whether a hexomino forms a cube (2). Lastly, many tasks which require the student's imagination are missing concrete three-dimensional verification methods. Therefore, students can be limited to their teacher's assessment without the possibility to visually comprehend the proposed solution (3).

Mathematikus.de – software-aided development of visuospatial abilities

Utilizing software allows for extensive variability: Virtual solids can be effortlessly created without being restricted to just a few physical solids. Additionally, it is possible to implement immediate visual feedback such as observable animations. We developed *mathematikus.de* based on commonly used exercises for fostering visuospatial abilities. On our poster, we depict various exercises we have implemented and explain our didactical considerations behind these tasks. We show how the implemented informative feedback should support the students' learning process. Our next step is examining the students' work and reasoning-strategies while solving the tasks presented in *mathematikus.de*. One of our key interests is how much prior experience with three-dimensional solids students need to grasp and solve tasks presented on the two-dimensional screen which merely allows for an abstraction of three-dimensional problems.

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