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To cite this version:

Ingi Heinesen Højsted. Guidelines for design of didactic sequences utilizing dynamic geometry affordances related to mathematical reasoning competency. Eleventh Congress of the European Society for Research in Mathematics Education, Utrecht University, Feb 2019, Utrecht, Netherlands. hal-02428249

HAL Id: hal-02428249
https://hal.science/hal-02428249
Submitted on 5 Jan 2020

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Guidelines for design of didactic sequences utilizing dynamic geometry affordances related to mathematical reasoning competency

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Keywords: Dynamic geometry environments, reasoning competency, research-based guidelines.

Identifying guidelines for fruitful teaching with technology in mathematics education is an important research objective. However, technology, such as dynamic geometry environments (DGE), can be used for different purposes. Therefore, to make sense of guidelines for teaching with DGE, it is necessary to clarify the mathematical aim of the teaching. To this end, the notion of mathematical competencies (Niss & Jensen, 2011), which includes the reasoning competency (RC), can be used. Research on DGE affordances has found potentials regarding development of students’ mathematical reasoning (e.g. Leung, 2015), which is promising, because students’ inadequate abilities in reasoning is well documented (e.g. Hoyles & Healy, 2007). However, students’ accessibility to DGE, does not guarantee greater learning outcome. The manner in which the DGE is used is essential (Jones, 2005). Therefore, to support the utilization of the potentials of DGE regarding RC, it is important to investigate: which research-based guidelines may be formulated for using DGE to support students’ development of RC?

An extensive review was conducted using the hermeneutic circle approach (Boell & Cecez-Kecmanovic, 2014), to map out potentials of DGE described in the literature. Initial searches were made with search words such as "dynamic geometry", "geometry software", "geometry technology", “interactive geometry” and “proof”, “reasoning”, “conjecture” in MathEduc and ERIC databases, as well as reading CERME technology TWG proceedings. After reading literature acquired from the primary search, interesting references were followed and if suitable, added to review. In addition, after reading and gaining some insight into the area of interest, adjusted search words were used in new searches. 136 publications were included. The definition of the RC played a decisive role in the review process. It influenced the choice of search words and was the optic used to decide which DGE potentials described in the literature were deemed relevant for this study.

In synthesizing the review findings, three categories of guidelines were identified: students’ cognition, task design and teaching practices. The guidelines emerge from the utilization of four types of DGE affordances: feedback, dragging, measuring and trace. Theoretical constructs from two predominant theoretical frameworks, the instrumental approach (Artigue, 2002) and the Theory of Semiotic Mediation (Bartolini-Bussi & Mariotti, 2008), were found to be suitable in the design of guidelines. Specifically, the notion of semiotic potential is useful in the consideration of what dimensions guidelines might entail. Furthermore, a description can be made of the instrumented techniques to be appropriated along with the utilization schemes needed. The role of the teacher can be described in supporting the mediated signs of the students towards mathematical meanings in order to support their development of RC. The guidelines are considered a priori in an ongoing project, in which the next step is to implement them in practice and refine them through a design-based research approach. To illustrate, table 1 below shows a segment from the a priori guidelines.
Instrumented techniques | Utilization schemes | Tasks | Teacher’s role | Reasoning competency
---|---|---|---|---
Constructing direct invariants, which induce indirect invariants because of Euclidean theory. | Understanding the difference between direct and indirect invariants, and the connection between them. | Construction tasks with direct invariants, where dragging free points in the construction unveils (surprising) indirect invariants. | Instruction, discussion and feedback: focus on mathematical meanings - Address that direct invariants can induce indirect invariants because of Euclidian geometry governing the environment. | Prerequisite for working on conjecturing tasks. Some initial conjecturing tasks.

Table 1: Example from a priori guidelines

References


