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Impact Sheet

Elkjær, M. & Hodgen, J. (2022). Operationalising Vergnaud's notion of scheme in task design in online learning environments to support the implementation of formative assessment. *Implementation and Replication Studies in Mathematics Education*, *2*(1), 21–44. DOI: 10.1163/26670127-bja10002

1 Problem Addressed

There is a great deal of evidence that formative assessment can have a positive impact on learning (Black & Wiliam, 1998). Indeed, formative assessment is one of the most widely adopted teaching and feedback provision strategies worldwide. However, attempts to promote formative assessment have often resulted in teachers facing substantial difficulties implementing these ideas. Online learning environments are increasingly playing a significant role in mathematics teaching and learning and have the potential to help teachers to enact formative assessment. These online environments can produce substantial assessment data with relatively little effort from teachers and can provide feedback directly to teachers and students. Indeed, despite an extensive research base on how diagnostic tasks performed and why the tasks are believed to be sensible choices for exploring certain areas of difficulty in learning mathematics (Rhine et al., 2018), little research has investigated how online learning environments can best provide feedback to enable teachers to diagnose student thinking and thus adapt teaching effectively to promote student learning. In particular, few papers have systematically addressed the considerations or design principles underlying the construction of diagnostic tasks to provide relevant feedback to teachers within the constraints of online learning environments.

Elkjær and Hodgen's (2022) paper addresses this problem by considering the case of linear equations and the equals sign in order to develop a framework for the design of tasks. The authors consider the following research question. How can the notion of scheme guide the design of diagnostic tasks for implementation in online learning environments, specifically regarding known difficulties with the concept of linear equations and the equals sign, to enable teachers to better interpret or hypothesise about learners' difficulties?

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2 What Is To Be Implemented?

Elkjær and Hodgen (2022) present a thought experiment in which they establish and illustrate a set of design principles using a sequence of linear equation tasks. The discussion considers the context of *matematikfessor.dk*, an online learning environment used by approximately 80% of Danish schools. As is typical for online learning environments, in *matematikfessor*, student responses are constrained. Only multiple-choice or numeric inputs are permitted. Hence, it is difficult for teachers to infer student thinking.

The authors use Vergnaud's (2009) notion of scheme together with the controlled variation (Watson & Mason, 2006) of tasks to show how this constraint can be utilised to provide feedback to teachers. Using the 'dual scheme idea' by Ahl and Helenius (2018), they construct a frame for designing a task sequence that is informed by the research evidence on students' thinking. A key feature is that the *expected* path to solving the task becomes increasingly more difficult, while the *preferred* path to solving the task remains equally easy. Building on this case, the authors develop an 'implementation process model' (Nilsen, 2015) for the design of tasks in online learning environments that can improve feedback for teachers and students.

3 Implications and Significance

The design on diagnostic tasks in online learning environments is poorly understood and the authors provide a theoretically grounded approach to the design of diagnostic tasks that overcome the constraints of these environments in order to provide feedback to teachers. The approach offers a way of utilising online learning environments to help teachers implement formative assessment. The next steps for the implementation process model include implementing the model in the design of further tasks in online learning environments, such as *matematikfessor*. It is also important to examine whether, and how, the resulting tasks actually enable teachers to hypothesise about their learners' schemes.

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