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Is there a role for direct instruction in problem-based learning? Comparing student-constructed versus integrated model answers

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ABSTRACT

Problem-based learning (PBL) requires students to formulate learning issues that need to be answered by studying multiple literature resources. Advocates of high instructional guidance argue that this is too cognitively demanding for students and ineffective for learning. Therefore, we examined the effects of studying an integrated model answer in the self-study phase in PBL. Participants ($N = 62$) engaged in a simulated group discussion, ending with the establishment of learning issues. Then they either studied integrated model answers to the learning issues, or undertook a standard PBL self-study phase in which students needed to construct their own answers based on multiple literature resources. Higher learning outcomes were obtained for the participants who studied integrated model answers when compared to the participants who constructed their own answers. These higher learning outcomes were obtained with lower investment of self-study and equal investment of mental effort during learning.

1. Introduction

Problem-based learning (PBL) was first introduced in the mid-sixties of the last century in medical education. Since then it has been implemented in various education curricula, such as economics and business education, engineering, science education, law, psychology, and K-12 education (Barrows, 1996; Loyens, Kirschner, & Paas, 2012; Schmidt, Van der Molen, Te Winkel, & Wijnen, 2009). Schmidt et al. described PBL as "one of the few curriculum-wide educational innovations surviving the 60s" (Schmidt et al., 2009, p. 228).

PBL was developed to demonstrate the relevance of learning subject matter by offering a more realistic context through the use of problems. After students are presented with a problem scenario, the PBL-cycle generally consists of three phases: (1) initial discussion phase, (2) self-study phase, and (3) a reporting phase. Collaborative learning takes place in the initial discussion phase and the reporting phase, whereas self-study is conducted individually. During the initial discussion phase the problem is presented to students before they receive any other curriculum input (Barrows, 1996; Schmidt, 1983; Schmidt & Moust, 2000). The problem is complex and usually describes a phenomenon or event that can be observed in daily life. Small groups of students collaboratively discuss this problem using their prior knowledge and common sense to come up with possible explanations for the problem. Because their prior knowledge is insufficient to explain the problem completely, they formulate learning issues (i.e., questions) for further self-directed study. During the self-study phase, students prepare themselves for the next tutorial meeting by selecting, studying, and integrating information from multiple relevant learning resources (e.g., scientific articles or book chapters) with the aim of finding an answer to the learning issues. Afterward, students meet again to discuss their findings and to come to an integrated answer to the learning issues (i.e., reporting phase).

In the present experimental study we investigate the effectiveness and efficiency of the self-study phase in terms of learning. First, the effectiveness and efficiency of PBL when compared to direct instruction are discussed. Second, potential benefits and disadvantages of the standard PBL self-study phase are discussed.

1.1. The effectiveness and efficiency of PBL versus direct instruction

Different views exist about whether or not PBL is an effective instructional approach. Proponents of PBL assume that the elaboration of knowledge that occurs at the time of learning will enhance subsequent retrieval and retention (Norman & Schmidt, 1992). A

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meta-analysis has found positive effects of PBL on long-term retention that were believed to be caused by students' active engagement with the learning materials (Dochy, Segers, Van den Bossche, & Gijbels, 2003). For example, several studies have demonstrated that PBL students score lower than a conventional lecture-based instruction group on multiple choice tests administered immediately after a course, but that their performance does not deteriorate on a follow-up test – on which they might even score better than the conventional instruction group (Eisenstaedt, Barry, & Glanz, 1990; Tans, Schmidt, Schade-Hoogeveen, & Gijselaers, 1986). Based on these studies, one might conclude that the PBL approach is an effective and efficient instructional method.

However, some researchers have questioned the effectiveness and efficiency of PBL. For instance, the responsibility and autonomy that students are offered is experienced as unstructured, chaotic, and stressful (Duke, Forbes, Hunter, & Prosser, 1998; Sierens, Soenens, Vansteenkiste, Goossens, & Dochy, 2006). Kirschner, Sweller, and Clark (2006) described PBL as an unguided or minimally guided instructional approach. They argued that such approaches lead to ineffective use of limited cognitive resources, and thus, are not optimally designed for learning. Solving complex problems without any prior knowledge of the solution procedure imposes high load on working memory and leads to slow and inefficient learning (i.e., schema formation or elaboration in long term memory; Clark, Kirschner, & Sweller, 2012; Kirschner et al., 2006; Sweller, Kirschner, & Clark, 2007). Accordingly, Kirschner and colleagues stated that PBL would be less effective and efficient than direct instruction, such as worked examples that show students the step-by-step procedure for solving a problem (Cooper & Sweller, 1987; Sweller & Cooper, 1985). In line with this view, a recent meta-analysis indicated that unassisted discovery learning in science, math, or problem-solving is less effective than explicit instruction such as worked examples and offering feedback (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). During unassisted discovery learning students have to discover the target information or come to conceptual understanding independently with only the provided materials.

In their reply to Kirschner et al. (2006), Schmidt, Loyens, Van Gog, and Paas (2007) explained why PBL should not be qualified as an unguided instructional approach and that sufficient scaffolding in various ways is present to reduce ineffective working memory load, for example by offering students a limited set of literature to choose from during the self-study phase. Alfieri et al. (2011) demonstrated that enhanced discovery learning, in which scaffolding and guidance was present, was beneficial not only compared to unassisted discovery learning, but also when compared to several types of explicit instruction. However no significant difference was found between enhanced discovery learning and worked examples. These findings suggest that PBL approaches can be beneficial for learning when sufficient scaffolding is present.

Moreover, as Schmidt et al. (2007) pointed out, the vast majority of studies favoring direct instruction, such as worked examples, over unguided instruction, have used well-defined problems. Well-structured problems have a clearly defined goal state and a constrained set of logical operators to reach that goal state and are commonly found in mathematics or science curricula (Jonassen, 1997). In contrast, the problems encountered in PBL are ill-defined. These problems do not have clearly specified goals or operators, and can have multiple correct solutions or solution procedures (Jonassen, 1997). As a consequence, Schmidt et al. stated that the findings with respect to well-structured problems might not generalize to a PBL context.

Nevertheless, recent studies indicated that instructional formats that provide high levels of guidance, such as worked examples or modeling examples, may also be effective for less well-defined tasks (e.g., Kostons, Van Gog, & Paas, 2012; Nievelstein, Van Gog, Van Dijck, & Boshuizen, 2013; Rourke & Sweller, 2009; Rummel & Spada, 2005; Schworm & Renkl, 2007). Modeling examples provide learners with the opportunity of learning by observing a peer or an adult model performing a to-be-learned task (Van Gog & Rummel, 2010). Findings from studies on worked examples and modeling examples suggest that direct instruction techniques might also be effective for acquiring knowledge of less well-defined problems, such as those encountered in PBL.

In summary, proponents of PBL emphasize the importance of students' active role during the learning process, such as giving them autonomy and having them actively construct their own knowledge based on multiple information sources, whereas advocates of high instructional guidance are concerned that the level of instructional guidance that is offered during the learning process is too low and that this might be detrimental to students' learning outcomes. In the present study, we investigate these contrasting views during the self-study phase of PBL. Specifically, we compared a group of participants who needed to construct their own answer to the learning issues by selecting, studying, and integrating information from multiple literature resources during self-study to a group of participants who studied integrated model answers. The integrated model answer constitutes an adequate "solution" or expert answer in which information from several resources is integrated. The model answer is comparable to the type of answer tutors in PBL receive to prepare themselves for group meetings.

1.2. Benefits and disadvantages of the self-study phase in PBL

One of the essential goals of PBL is to develop autonomous learners and enhance students' self-directed learning skills (Norman & Schmidt, 1992; Schmidt et al., 2009). Self-directed learning refers to the ability of students to be in control of their own learning process, rather than being directed by their teachers (Loyens, Magda, & Rikers, 2008). The experience of autonomy is not only a central concept in self-directed learning; it also is a central component of self-determination theory (Deci & Ryan, 2000). Self-determination theory differentiates between autonomous and controlled motivation. Students are autonomously motivated when they experience self-determination, volition, and internal control over their learning process. Students study because the task is interesting (i.e., intrinsic motivation) or personally meaningful for future life goals (i.e., identified motivation). An autonomous learner is therefore also self-directed. In contrast, students with controlled motivation experience either internal pressure to study, such as avoiding feelings of shame or guilt (i.e., introjected motivation) or external pressure, such as threat of punishment (i.e., external motivation).

Thus, self-directed learning can be seen as a skill a learner already has (e.g., learners who are more autonomously motivated are more self-directed), or as a design feature of the learning environment (e.g., the way instruction is organized) that leads to more autonomous motivation and self-direction (Candy, 1991). For example, in most PBL programs students have the responsibility to choose their own literature resources, based on the learning issues that were formulated during group discussion (Schmidt et al., 2009).

1.2.1. Benefits of the self-study phase in PBL

The standard PBL self-study phase in which students need to choose or select, study, and integrate information from multiple literature resources with the aim of finding an answer to the learning issues, might have potential motivational benefits. First, choosing one's own literature resources might yield benefits for students' intrinsic motivation and perceived competence. A meta-