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A step further in Peer Instruction: Using the Stepladder technique to improve learning

Nicolas Michinov [a, *], Julien Morice [b], Vincent Ferrières [c]

[a] Université Rennes 2 (CRPCC, EA 1285), France
[b] Université européenne de Bretagne, France
[c] Ecole Nationale Supérieure de Chimie de Rennes (CNRS, UMR 6226), France

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ABSTRACT

Peer Instruction (PI) is an instructional strategy for engaging students during class through a structured questioning process that improves the learning of the concepts of fundamental sciences. Although all students are supposedly engaged in discussions with their peers during Peer Instruction, the learning gains generally remain at a medium level, suggesting a lack of participation of certain students who do not benefit from social interactions. The present study examined whether the Stepladder technique might optimize the Peer Instruction method and increase learning gains. With this technique, students enter a group sequentially, forcing every group member to participate in discussions. Eighty-four chemistry students were asked to answer easy and difficult multiple-choice questions before and after being randomly assigned to one of three instructional conditions during a chromatography lesson (Classic PI vs. Stepladder PI vs. Individual Instruction without any discussion with peers). As predicted, results showed that learning gains were greatest in the Stepladder PI group, and that this effect was mainly observed for difficult questions. Results also revealed higher perceived satisfaction when students had to discuss the questions with their peers than when they were not given this possibility. By extending the Stepladder technique to higher education, these findings offer a step forward in the Peer Instruction literature, showing how it can enhance learning gains.

1. Introduction

Peer Instruction (PI) is an interactive student-centred instructional strategy for engaging students in class through a structured questioning process that improves the learning of the concepts of fundamental sciences. Although a number of studies have revealed that the Peer Instruction method produces greater learning gains than more traditional instructional methods such as lectures, the gains generally remain at a medium level (e.g., Crouch, Watkins, Fagen, & Mazur, 2007; Crouch & Mazur, 2001; Hake, 1998; Mayer et al., 2009; Mazur, 1997). One reason may be found in the premise that all students in groups are actively engaged in fruitful discussions with their peers during a PI session. However, evidence suggests that a substantial number of individuals are reluctant to communicate their ideas verbally in group and classroom settings for fear of being judged by others (e.g., McCroskey & Beatty, 1984; Micari & Pazos, 2014). Some experimentally tested techniques, such

* Corresponding author. Université Rennes 2 (CRPCC, EA 1285), Place du Recteur Henri Le Moal, CS 24307, 35043 Rennes Cedex, France.
E-mail addresses: nicolas.michinov@univ-rennes2.fr (N. Michinov), julienmorice@gmail.com (J. Morice), vincent.ferrieres@ensc-rennes.fr (V. Ferrières).

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as the Stepladder technique (e.g., Rogelberg, Barnes-Farrell, & Lowe, 1992; Rogelberg & O'Connor, 1998), have been shown to increase participation in groups because the entry of members is structured in such a way that every individual is required to contribute to the discussion in turn. To our knowledge, no studies have examined the use of this technique outside the laboratory, particularly in the sciences in higher education where students have to learn difficult concepts. As this technique is known to boost participation and performance in groups, it is reasonable to consider that it may also optimize the Peer Instruction method. Consequently, the purpose of the present study was to examine whether the Stepladder technique, known to improve performance in groups by actively engaging all members, might optimize the efficacy of Peer Instruction.

1.1. The Peer Instruction method to improve learning

1.1.1. Main findings in Peer Instruction and related socio-constructivist methods

The Peer Instruction method was initially developed by the Harvard physicist Eric Mazur (1997) for a course entitled “Physics for Non-Majors”. This method changes the traditional lecture format to one in which the instructor poses questions during the lecture, in order to engage students actively in discussions with their peers and focus their attention on central concepts (e.g., Crouch et al., 2007; Crouch & Mazur, 2001; Mazur, 1997). By providing opportunities for students to address difficult aspects of course material, Peer Instruction enables them to learn from each other by sharing ideas and solutions. It was initially introduced to promote interactions between physics students, who had to answer multiple-choice questions of the Force Concept Inventory (FCI; Hestenes, Wells, & Swackhamer, 1992) using personal response systems or clickers.[1] For more than a decade, Peer Instruction has been recognized by scientists as an efficient instructional method that enhances deeper learning by encouraging students to interact with their peers instead of staying passive (e.g., Crouch et al., 2007; Crouch & Mazur, 2001; Mazur, 1997). Although different versions of this method have been used, it is usually organized as follows: students vote individually on the correct answers to multiple-choice questions using clickers; if there is a moderate percentage of correct answers, the teacher asks the students to discuss the questions with their neighbours for 2–3 min; they then vote individually again on the same questions. The sequence generally ends with a whole-class discussion in which the instructor provides explanations about the concepts. Although this is the most generally recommended way of using the Peer Instruction method (Mazur, 1997), a wide variety of variants has been observed, and a study revealed that less than 12.8% of the teachers using Peer Instruction do so as it was originally designed to be implemented (Dancy & Henderson, 2010). More broadly, a typical Peer Instruction sequence resembles a 'Think-Pair-Share' learning strategy (e.g., Watkins & Mazur, 2010), whereby students have to think individually about questions before sharing ideas and solutions with their classmates, either in pairs or in three- or four-member groups.

Peer Instruction is thus similar to other learning methods based on interactions with peers, such as Peer feedback (e.g., Van Zundert, Sluijsmans, & Van Merriënboer, 2010) and Peer-led Team Learning (e.g., Hockings, DeAngelis, & Frey, 2008). The former has been used essentially to improve students' writing skills, and involves equal-status learners giving comments/feedback to their peers. This method has been shown to improve several aspects of learning (e.g., Gielen, Peeters, Dochy, Onghena, & Struyven, 2010). Similarly, the Peer-led Team Learning method has been used to improve learning in chemistry classes, and involves good students becoming leaders of small groups of students, helping them solve problems through discussion and debate. Studies have demonstrated learning improvements with these methods compared to traditional lectures (e.g., Hockings et al., 2008; Lewis & Lewis, 2005; Wamser, 2006). The benefits of peer discussions for learning have also been demonstrated in a large variety of other instructional methods, such as reciprocal teaching (e.g., Rosenshine & Meister, 1994), peer tutoring (e.g., Fantuzzo, Riggio, Connelly, & Dimeff, 1989; Palincsar & Brown, 1984), and (Computer-Supported) collaborative learning (e.g., Goodyear, Jones, & Thompson, 2014), including 'collaboration scripts' (e.g., Kobbe et al., 2007; Weinberger, Fischer, & Mandl, 2002). Many other instructional methods based on cooperative learning have been described in the literature (see Johnson & Johnson, 2008; Slavin, 2011), including Student Teams-Achievement Divisions (STAD), Teams–Games–Tournaments (TGT), Group Investigation (GI), and Jigsaw Grouping. Like Peer Instruction, all these methods and instructional strategies are based on a social constructivist approach to learning, in which social interaction plays a crucial role in the construction of knowledge, and where discussion and collaboration between peers have a positive impact on learning (e.g., Dillenbourg, Baker, Blaye, & O'Malley, 1996; Doise & Mugny, 1984; Springer, Stanne, & Donovan, 1999). All these methods indicate that learning is not only the product of individual cognitive processes, but that it can be improved through group discussion, helping students develop a deeper understanding of what they are learning.

Since it was first developed by Mazur (1997), the Peer Instruction method has been widely recognized by scientists to have a positive impact on learning, particularly for difficult concepts of fundamental sciences such as physics and chemistry (e.g., Crouch & Mazur, 2001; Crouch et al., 2007; Fagen, Crouch, & Mazur, 2002; Lasry, Mazur, & Watkins, 2008), although it is not limited to these two disciplines (e.g., Rao & DiCarlo, 2000; Zingaro & Porter, 2014). It has generally been demonstrated to be more effective than traditional methods without peer interaction, such as lectures attended by a large number of students (e.g., Hake, 1998; Mayer et al., 2009) and individualized learning (e.g., Jones, Antonenko, & Greenwood, 2012; Lasry, Charles, Whittaker, & Lautman, 2009). In contrast to traditional learning methods, Peer Instruction was designed to involve all the students in solving problems through peer discussion, thereby improving the learning of difficult concepts (Zingaro & Porter,

[1] Personal response systems, also named “clickers”, allow students to answer questions in class providing real-time and anonymous feedback that can be used by students to share their ideas and solutions with others (e.g., Banks, 2006; Lantz, 2010).