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The relationship between students' prior mathematical attainment, knowledge and confidence on their self-assessment accuracy

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ABSTRACT

The ability of students to assess their own performance accurately may allow them to self-regulate their learning through metacognitive monitoring. This research investigates factors affecting undergraduate radiation physics students' ability to self-assess their work accurately in a mathematical subject test. The factors investigated are demographics, mathematics confidence, prior mathematical attainment and prior level of mathematical knowledge. Students' accuracy of their self-assessment was found to be associated with their prior mathematical attainment and their overall mathematics confidence. Students with high and low prior mathematical attainment self-assessed more accurately than students who had moderate prior attainment. These results have implications for how students may determine their own learning strategies and the pedagogical use of summative self-assessments.

1. Introduction

This paper investigates the relationship between the factors of self-confidence, prior knowledge level and attainment in relation to students' accuracy of their self-assessment in mathematical subjects at the undergraduate level. Self-assessment is a part of the self-regulation process (Panadero & Alonso-Tapia, 2013; Zimmerman, 2008). Zimmerman (2008) explains that the self-regulation process is an internal proactive process that students use to self-monitor themselves to set goals and determine future strategies. Self-regulation consists of a three-phase cycle: the forethought phase, the performance phase and the self-reflection phase, i.e. before, during and after an event (see Zimmerman & Campillo, 2003). Self-assessments occur during the self-reflection phase in which students are judging or evaluating themselves by reflecting on their metacognitive monitoring process during the performance phase (Panadero & Alonso-Tapia, 2013). Through self-assessment, students reflect on the event during the performance phase to help them create appropriate learning strategies for the future with the goal of improving their mastery of the subject (Nicol & Macfarlane-Dick, 2006; Pintrich, 2004; Schunk, 1990; Virtanen & Nevgi, 2010; Zimmerman, 1990). Therefore, self-assessment is a mechanism for providing internal feedback about the event. Students are hence encouraged to engage in the metacognitive strategy of self-assessment. This strategy can improve students' judgement of their performance and help them to monitor the gap between their performance and the required standard (Thompson, 2013, 2015; ; Kruger & Dunning, 1999). Performance, in this context, is a mechanism that provides external feedback about the event.

There are, however, contentions as to what signifies a self-assessment (see Panadero, Brown, & Strijbos, 2015 for review), particularly about how students assess their work, that is, whether it is a qualitative or quantitative self-assessment. Panadero and Alonso-Tapia (2013) indicate that self-assessments should primarily aim to help the self-regulatory learning processes of a student and not only be an instructional process used by a teacher. Further, they indicate that to enable metacognitive monitoring, the purpose of students' self-assessment should not be about the quantitative feedback on their performance such as a score but rather the qualitative feedback on how they can improve themselves, that is, the self-assessment should be 'for learning' not 'of learning'. Whilst we agreed with this position, there is, however, merit in students being able to quantitatively self-assess or self-evaluate their work accurately, particularly within educational systems which assess them in this way (see Brown & Harris, 2013). Further, students often quantitatively self-assess their work spontaneously, particularly at the undergraduate level, which helps them in judging whether they have done sufficiently well to obtain academic credit (i.e. pass the assessment). Accurate quantitative self-assessment can enable students to be more realistic about their outcome expectations as well as having self-awareness of the level of perfection they are likely to achieve (see Panadero & Alonso-Tapia, 2013) which can affect the motivational and

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affective aspects of their self-regulation, that is, the forethought phase.

In this study, we use self-assessment to refer to students' quantitative estimation of their performance on an assessment. We consider two versions of this estimation. The first is an inaccurate estimation that represents the extent the self-assessment is dissimilar to the actual performance. The second is a bias estimation. This is the extent students overestimate or underestimate their self-assessment. This paper will look at how certain factors acting together affect these two types of estimations of students' self-assessment within the self-regulation process.

1.1. Factors affecting self-assessment accuracy

There are several factors that affect students' accuracy of their self-assessment but it is unclear how these factors affect the level of bias, that is, the overestimation or underestimation of performance (see Boud & Falchikov, 1989; Nulty, 2011; Panadero et al., 2015 for a review of studies). In their review, Panadero et al. (2015) noted three factors that affect self-assessment accuracy: students' knowledge of self-assessment criteria, their performance or achievement level and the level of students' expertise. They indicated that when the assessment criteria were concrete, understood and well specified for the students, students were more likely to self-assess accurately. In mathematical subjects where there is a clear right or wrong answer (Sadler, 1989 refers to this as "sharp" criteria), there is perhaps less need for concrete assessment criteria than in subjects such as literature and history where the performance quality is more subjective, that is, they have "fuzzy" criteria. Therefore, in sharp criterion subjects, students' metacognitive monitoring processes during the performance phase is likely more specified. Thus, the accuracy of a students' self-assessment may be more comparable to a teachers' grading as it is not wholly subjective (see Brown, Andrade, & Chen, 2015). This is a possible reason that Panadero et al. (2015) suggested that students' self-assessment accuracy may be higher in science subjects than in other subjects.

With respect to performance or achievement level, several studies showed that these calibrate well with students' self-assessment (see Beyer, 1999; Boud & Falchikov, 1989; Moreland et al., 1981; Zimmerman, 2008). Boud and Falchikov (1989) in their systematic review (and more recently by Kun, 2015; Langendyk, 2006; Panadero et al., 2015) noted that high achieving students were more likely to realistically estimate (or underestimate) their performance than the low achieving students, who tended to overestimate. In these studies, high achieving students were denoted based on students' performance on the current assessment and did not account for their prior attainment. However, there is some indication that attainment levels can affect self-assessment accuracy. For example, Lew, Alwis, and Schmidt (2010) found that students with a high-grade point average (GPA) were more likely to self-assess accurately but they did not provide the direction of bias. It is likely, that students who have better prior attainment grades are also high-achieving students and therefore will self-assess more accurately and realistically (that is a low inaccuracy) and may tend to underestimate their performance. Therefore, our first two hypotheses are:

Hypothesis 1. *Prior attainment will have a negative relationship with inaccuracy.*

Hypothesis 2. *Prior attainment will have a negative relationship with bias.*

A related concept to prior attainment is knowledge level. Knowledge level is the expertise that students have gained in a particular area by spending more time on it such as through advanced study. Boud and Falchikov (1989) noted that students who were in the later years of their degree programmes (high knowledge) tended to estimate their performance more accurately than those in early years of the programme (low knowledge). This occurred for possibly two reasons. Firstly, students might estimate more accurately because they know the area well, for example, students reading advanced calculus may gauge their current performance based on their prior performance in basic calculus (Pajares & Miller, 1994). Secondly, students are probably better able to predict their performance because of growing awareness and experience of how assessments are marked by spending time within the educational system (Boud et al., 2013). Nietfeld and Schraw (2002) also found that the level of prior knowledge (or expertise) affected students' performance and self-assessment accuracy but not their level of bias (that is overestimation or underestimation). They found that on a probability test, students with high prior knowledge (advanced undergraduate courses in mathematics) were significantly more accurate in estimating the likelihood of correctly answering a question than students with low (no undergraduate courses in mathematics) and middle (introductory undergraduate courses) prior knowledge. In their study, however, they did not account for the quality of the prior knowledge, that is, students' prior attainment and whether the students' prior attainment of a high or low grade in their mathematical courses could have influenced bias (see Hypothesis 2).

Additionally, prior attainment may affect knowledge level, as those who do well in a subject area are more likely to continue studying the subject area at an advanced level and hence may have more expertise (see for example Noyes & Sealey, 2012). Also, university students have varied educational backgrounds (e.g. due to age, work experience) and will have different prior knowledge levels as well as different attainment in these prior knowledge levels (see for example Perkin, Pell, & Croft, 2007). The combination of students' prior attainment and prior knowledge level, therefore, may influence how accurately students can estimate their performance and bias. It is uncertain of the exact relationship between the combined effects of prior attainment and prior knowledge level with self-assessment accuracy, as it is unknown whether prior attainment is a stronger influencer on self-assessment accuracy than prior knowledge level. However, prior attainment can drive self-efficacy (Sitzmann & Yeo, 2013) which is part of the self-regulated cycle. Therefore, we will expect that students with high prior attainment but low expertise are probably better self-regulated learners and self-assessors than students with low prior attainment and high expertise. Therefore, our second set of hypotheses based on prior attainment and level of knowledge (expertise) is:

Hypothesis 3. *The knowledge (expertise) will have a relationship with inaccuracy.*

Hypothesis 4. *The knowledge (expertise) will have no relationship with bias.*

Hypothesis 5. *The interaction of level of knowledge (expertise) and prior attainment will have a relationship with inaccuracy.*

Hypothesis 6. *The interaction of level of knowledge (expertise) and prior attainment will have a relationship with bias.*

The systematic reviews discussed hitherto point out that self-assessment influences self-efficacy. Bandura (1986) defined self-efficacy as "people's judgement of their capabilities to organise and execute courses of actions required to attain designated types of performance" (p.391). Self-confidence is often operationalised as a measurement of self-efficacy (Schunk, 1991). Bandura (1997) objects to this operationalisation as he indicates that confidence refers to the strength of a person's belief in their capabilities but not necessarily the certainty of attaining these capabilities. Self-efficacy should, therefore, be task specific, but often it is measured at a global or at a domain level (Pajares, 1996) with the global level perhaps being more representative of self-confidence. Further in the literature, both self-confidence and self-efficacy are used sometimes interchangeably (see for example McMullan, Jones, & Lea, 2012), for this reason, the approach taken in this paper is to use the terminology of self-confidence as it encompasses self-efficacy.

It is surprising that as students' self-confidence is positively related