Received: 17 August 2022 | Revised: 18 June 2023 | Accepted: 12 August 2023

DOI: 10.1111/jcal.12868

ORIGINAL ARTICLE

Journal of Computer Assisted Learning WILEY

Where less is more: Limited feedback in formative online multiple-choice tests improves student self-regulation

Richard Say[1] | Denis Visentin[1] | Annette Saunders[1] | Iain Atherton[2] | Andrea Carr[1] | Carolyn King[1]

[1]College of Health and Medicine, University of Tasmania, Alexandria, New South Wales, Australia

[2]School of Health and Social Care, Edinburgh Napier University, Edinburgh, Scotland

Correspondence
Richard Say, College of Health and Medicine, University of Tasmania, Locked Bag 5052, Alexandria, NSW, Australia.
Email: richard.say@utas.edu.au

Abstract

Background: Formative online multiple-choice tests are ubiquitous in higher education and potentially powerful learning tools. However, commonly used feedback approaches in online multiple-choice tests can discourage meaningful engagement and enable strategies, such as trial-and-error, that circumvent intended learning outcomes. These strategies will not prepare graduates as self-regulated learners, nor for the complexities of contemporary work settings.

Objectives: To investigate whether providing only a score after formative online multiple-choice test attempts (score-only feedback) increases the likelihood of students to engage in self-regulated learning compared with more directive feedback. Measurable outcomes included deeper learning, collaboration, information seeking, and satisfaction.

Methods: Data in this mixed methods study were collected from nursing students through surveys, test results, focus groups, and student discussion board contributions. A quasi-experimental design was used for quantitative data, and qualitative data were analysed thematically against domains of self-regulated learning.

Results and Conclusions: Students receiving score-only feedback were more cognitively engaged with the content, collaborated constructively, and sought out richer sources of information. However, it was also associated with lower satisfaction. In this study, minimal feedback created states of uncertainty, which resulted in the activation of self-regulatory actions.

Implications for Practice: Providing overly directive feedback for formative online multiple-choice tests is conducive to surface-level learning strategies. By minimising feedback and allowing for extended states of uncertainty, students are more likely to regulate their learning through self-assessment and problem-solving strategies, all of which are required by graduates to meet the challenges of real-world work settings.

KEYWORDS

adult learning, assessment, cooperative/collaborative learning, distance education and online learning, lifelong learning, pedagogical issues

1 | INTRODUCTION

Undergraduate education must prepare students for the challenge of transitioning to increasingly complex work settings. Stephenson (1992) identified these challenges over 30 years ago when referring to increasingly voluminous knowledge and information, changing technologies, new techniques for disseminating information, more complex and diverse work contexts, and growing interdependence in workplaces. Decades later, these observations about complex and uncertain workplaces remain relevant as ever and are epitomised by the challenges faced by nurse graduates in healthcare settings.

Higher acuity patients, advancing technologies, growing specialisation, and shorter patient stays in acute environments are global phenomena that add complexity to the work required of new graduate nurses. One can only speculate how healthcare will continue to change, and what the demands on future nurses will look like. Educationalists can no longer teach a set of core competencies with an expectation that a future career is set in stone. Rather, pre-registration nursing programs must support the development of a broad set of *capabilities* that enable graduates to adapt and thrive in complex and uncertain healthcare environments (Christiansen et al., 2018; Harrison et al., 2019).

This paper examines how feedback in formative online multiple-choice tests (MCTs) might promote the development of graduate capabilities by using uncertainty. Formative feedback cannot simply aim to relate information from expert to novice, facilitating nothing more than simplistic rote learning. Rather, it must be carefully constructed to be meaningful and lasting by supporting students to regulate their own learning (Boud & Molloy, 2013). While repeatable online MCTs are widely used in higher education, the main feedback approaches traditionally used on their completion tend to transmit information in a surface-level way that encourages trial-and-error learning. The applicability of these learning approaches has limited utility in contemporary workplaces.

With these challenges in mind and the goal of enabling learning approaches that students can use throughout their careers, this study aimed to assess the impact of *score-only feedback* on nursing students' self-regulatory learning strategies. This feedback approach provides nothing other than a score at the end of each MCT attempt. It removes any indication of the correctness of individual responses and thus elicits a state of uncertainty that the test-taker must resolve on subsequent attempts. It was hypothesised that minimising feedback would require a deeper cognitive engagement with the task and encourage learning strategies such as information seeking and collaboration. Approaches that, once embedded, can form the bedrock of a professional nurse's career. It was posited that these actions in response to score-only feedback represent a more authentic replication of the capabilities required by graduate nurses as they transition to challenging practice environments.

2 | BACKGROUND

2.1 | Online multiple-choice tests and feedback

Despite being labelled 'yesterday's news' over a decade ago (Roberts, 2006), online MCTs continue to be used as formative assessment activities. In a systematic review of formative assessment and feedback, Morris et al. (2021) identified low-stakes quizzing[1] (including online MCTs) as a powerful formative assessment approach. However, they note that research supporting these tools is 'limited and patchy' (p. 20).

Formative online MCTs are widely used in education, providing efficiencies that significantly reduce the burden of large student numbers. Online MCT development and application to computerised environments is relatively straightforward, allowing student performance to be easily graded and collated. Once developed, students can use online MCTs at times and places of their choosing without the requirement of ongoing educator input. In addition to these efficiencies, the widespread use of online MCTs is supported by their pedagogical merits. Regular recurrent online MCTs (and online quizzes in general) have been shown to promote skills such as self-pacing, independence, and time management (Reime et al., 2008), build learner confidence and improve exam performance (Say et al., 2022), and are effective in supporting flipped classroom approaches (Hughes et al., 2020).

One of the key attractions of using online MCTs is their ability to deliver immediate, private and nonintimidating individualised feedback to large cohorts (Kuklick & Lindner, 2021; Mason & Bruning, 2001; Wilson et al., 2011). The power of feedback is amplified by the opportunity to repeat tests. This process was emphasised by Buchanan (2000)—an early adopter of repeatable formative online MCTs—who referred to the 'test-learn-retest' cycle. On completion of an MCT attempt, the learner could use feedback to identify key areas for further study before repeating the test. This approach has since been used extensively in the design of online MCTs and is endorsed because it allows students to 'experience a closing of the gap between desired and actual performance' (Nicol, 2007, p. 59), encapsulating the essence of formative assessment. Given the centrality of feedback to the success of formative online MCTs, the type of feedback and how it is used warrants careful consideration.

2.2 | Feedback types

While many variables determine how students interact with online MCTs, such as question difficulty, grading, and characteristics of learners (Hughes et al., 2020; McNulty et al., 2015), feedback has been the most extensively researched in computer-based learning literature. Item-based, automated feedback in computer-based learning can broadly be sorted into two categories. Verification feedback tells students whether their answer is right or wrong (*knowledge of results* [KR]) and sometimes identifies the correct answers (*knowledge of correct response* [KCR]) (Kuklick & Lindner, 2021; van der Kleij et al., 2015). *Elaborated feedback* (EF) provides further information to the student on the completion of a question or set of questions. For example, a student may be given information about where to find an answer or provide an explanation about why a particular answer is correct (see

[1]Multiple-choice tests (MCTs) include a series of exclusively multiple-choice questions. For the purposes of this paper, a *quiz* contains a variety of question types such as multiple-choice, fill-in-the-blank, and matching questions.

Mason and Bruning (2001) for other examples of EF). Elaborated feedback is almost always combined with verification feedback (Candel et al., 2021) and is generally viewed as the most effective automated feedback method (Mason & Bruning, 2001; van der Kleij et al., 2015). As noted by Hao et al. (2022), hundreds of studies have adopted the above feedback classification inclusive of KR, KCR, and EF.

However, despite decades of research and commentary on verification and elaborated feedback in computer-based learning, there is virtually no reporting on the use of a *score-only* approach. As the name suggests, with score-only feedback, an overall score is provided on the completion of each test attempt with no indication as to which questions are right or wrong. Only two references were located in the literature that discussed the use of score-only feedback for formative online MCTs. Cook and Babon (2017) used score-only feedback in their online MCT study on the basis that it required meaningful engagement with learning materials. However, the authors did not evaluate their feedback approach to student engagement or performance. Anderson and McDaniel (2021) observed that students receiving score-only feedback, referred to as 'minimal feedback' in their study, performed as well in a summative test as those receiving KR and KCR (Experiment 1). However, as with much of the research on feedback that is conducted in the field of cognitive psychology, the study by Anderson and McDaniel (2021) took place in a controlled setting and was limited in the extent to which it replicated formative assessment in authentic learning environments. Thus, given the limited reporting on score-only feedback, further research on this feedback approach for formative purposes is justified.

2.3 | Formative feedback and self-regulated learning

Feedback is central to formative assessment and is considered one of the most powerful learning tools at an educator's disposal (Hattie & Timperley, 2007). For formative feedback to have meaningful and lasting impacts on student development, it must be carefully constructed to support students in regulating their learning rather than merely relaying information from an expert to a novice (Boud & Molloy, 2013). However, the three main feedback types used in repeatable online MCTs—knowledge of results (KR), knowledge of correct response (KCR), and elaborated feedback (EF)—tend to transmit information in a way that may facilitate surface-level and trial-and-error learning. They remove any requirement for the student to resolve uncertainty and engage powerful learning processes. These limitations can be analysed from a self-regulated learning (SRL) perspective.

Contemporary conceptions of SRL are complex, dynamic, and not easily defined (Panadero, 2017). Core principles that have persisted for decades have posited that SRL involves an interplay of cognitive, metacognitive, behavioural, and motivational domains of learning that the learner modulates to achieve learning goals (Panadero, 2017; Pintrich, 2004; Winne, 1995). The self-regulated learner possesses the metacognitive ability to monitor learning, the cognitive assets to generate internal feedback (rather than solely relying on external feedback), and a behavioural aptitude to *seek* feedback from reliable sources (Hattie & Timperley, 2007). This paper considers student engagement as measured against these SRL domains. Additionally, satisfaction, which relates to the motivational aspect of SRL, is considered. The domains of SRL are broadly defined, overlap and the roles of each are emphasised differently by different theorists. Sinatra et al. (2015) argue that these broad definitions are problematic when measuring student engagement. Thus, the following definitions are used based on their relevance to online MCTs and utility in measuring engagement.

The domain of cognition is described in most models of SRL. Cognitive engagement can be defined as the psychological investment by students to understand through problem solving and deeper cognitive processing (Sinatra et al., 2015). This definition is well placed to describe the low level of cognitive engagement that occurs when students are told that an answer is right or wrong when completing online MCTs. Such feedback allows students to narrow down the available options systematically, failing to engage the deeper cognitive processing synonymous with self-regulation. Information is essentially transmitted to learners without requiring the student to process it internally and construct their own understanding. As Nicol and Macfarlane-Dick (2006) argued, externally delivered feedback that merely involves telling is the antithesis of constructivist logic, negating efforts to engage students in SRL processes. This adds weight to broader criticism of multiple-choice style questions, for which the selection of pre-determined options leaves little room for the construction of answers (Nicol, 2007).

Similarly, being told whether an answer is right or wrong limits the metacognitive action required by students. Metacognition subsumes various domains of SRL (Panadero, 2017; Sitzmann & Ely, 2011). However, metacognitive monitoring is particularly relevant in highlighting the limitations of verification feedback. Metacognitive monitoring includes error detection in cognition (Fernandez-Duque et al., 2000), a process that is a critical antecedent to triggering cognitive and behavioural actions required for change (Pintrich, 2004). Where KR and KCR identify the correctness of answers on completion of an MCT, there is no requirement for the students to engage in an error-detection process.

Verification and elaborated feedback are also limiting from a behavioural perspective. While recognised as a strength of online MCTs, providing immediate feedback and repeatability presents the opportunity for trial-and-error, allowing students to circumvent intended learning outcomes (Cook & Babon, 2017; Morrison et al., 1995). The focus becomes passing with learning being of secondary, if any, consequence. Two examples of behavioural engagement are information seeking and peer dialogue (Sinatra et al., 2015), which are relevant to online MCTs. Information seeking, such as reference to textbooks, tests, notes and other subject resources, is recognised as a self-regulatory behaviour (Butler & Winne, 1995; Zimmerman, 1986, 2002) and is cited as a reason for using online quizzes (Buchanan, 2000; Hughes et al., 2020). However, when a student can rely entirely on feedback provided by the MCT to correct errors or provide further explanations, there is no need to seek further information to address a performance gap.

Seeking help from peers is also recognised as self-regulatory behaviour (Pintrich, 2004). Feedback from other students can be easier to accept and understand, and exposes students to different perspectives and strategies (Nicol & Macfarlane-Dick, 2006). Additionally, peer feedback is received with a level of caution and uncertainty, leading to deeper learning (Draper, 2009). Thus, feedback occurs not only in the absence of teachers, but can be more effective when generated between students.

Nevertheless, despite empirical support for collaboration as a powerful learning approach, there are mixed views on whether it should be allowed in asynchronous online quizzes. Literature reporting on students working together to complete online quizzes often refers to 'dishonesty', 'cheating' and 'collusion' (Sullivan, 2016; Wideman, 2011; Woeste & Barham, 2008). Literature elsewhere has reported on the value of peer learning in completing online quizzes, including using discussion boards to facilitate deeper learning through collaboration (Einig, 2013; Limniou & Smith, 2014). These varied positions may pertain to the different intended learning outcomes of online quizzes. However, where an objective is to promote students' self-regulation, peer dialogue should be encouraged.

A final consideration discussed here, pertaining to how students engage with online MCTs, is satisfaction. Satisfaction is a commonly cited outcome for studies investigating online MCTs (Say et al., 2022), and students have previously expressed greater satisfaction with more directive MCT feedback (van der Kleij et al., 2012). Deci and Ryan (2008) argue that satisfaction is a driver of intrinsic motivation and, when driven by feelings of competency, autonomy and relatedness, can lead to positive 'psychological, developmental, and behavioural outcomes' (p. 15). However, satisfaction as a metric for quality education has been widely critiqued. The language used to measure satisfaction in surveys often describes feedback as a teacher-centred process (Winstone et al., 2022). Students tend to favour didactic teaching approaches over dialogic educational approaches; the latter requiring students to engage deeply with materials and actively construct their own understanding. This, argues Carpenter et al. (2020), relates to an illusion where students incorrectly perceive greater learning through being told information rather than the 'disjointed, less fluent experience' of active learning (p. 140). Therefore, while students may express satisfaction with directive feedback in online MCTs, it does not necessarily equate to deeper learning.

In summary, the types of feedback used in online MCTs can inhibit students' metacognitive, cognitive, and behavioural engagement. It is also questionable whether students' expressions of satisfaction with more didactic feedback types (such as KR, KCR and EF) reflect learning outcomes that are synonymous with the actions of a self-regulated learner.

2.4 | Work readiness

An impetus for this study was to consider how aspects of nurse education prepare students with the capabilities required to work in contemporary healthcare environments. Supporting learners to develop a disposition for self-regulation has implications for work readiness. Contemporary workplaces, shaped by the demands of a knowledge-driven economy and rapidly changing technologies, are complex and constantly evolving (Coetzee, 2014; Winterton & Turner, 2019). A key argument for learning strategies that promote self-regulation is that self-regulated learners are lifelong learners who can responsively direct their learning to areas of need (Nicol & Macfarlane-Dick, 2006). Just as the self-regulated student is an autonomous learner (Clark, 2012), the capable employee is an autonomous worker who can manage unfamiliar problems in unfamiliar contexts (Stephenson, 2013). Despite their autonomous approach to learning, Zimmerman (2002) noted that self-regulated learners are not defined by 'their reliance on socially isolated methods of learning' (p. 70), but rather by their initiative to adopt behaviours that enhance learning – such as seeking help from others. Similarly, work-ready graduates demonstrate the capability to problem solve, work in teams, and effectively seek help as they adapt and thrive in real-world settings (Bennett & Ananthram, 2022; Coetzee, 2014). Given these synergies between SRL and work readiness, it is incumbent on higher education providers to consider how feedback promotes self-regulation and places students at the centre of the learning process.

Nurse education provides an exemplar of this remit. Healthcare is increasingly complex, requiring nurses to expand their skills and knowledge as they adapt to rapidly evolving and specialised practice settings (Bromley, 2017; Lin et al., 2016). Nevertheless, it has been argued that student nurses are poorly prepared to manage the uncertainty pervasive in healthcare environments (Thompson & Yang, 2009). A study by Cranley et al. (2012) identified four distinct actions nurses undertook when successfully managing uncertainty. Firstly, they needed to recognise their uncertainty by assessing a situation and reflecting on their knowledge, experience, and judgements. They then managed uncertainty by 'figuring it out', collaborating, and seeking out reliable information. These actions all correlate to the metacognitive, cognitive, and behavioural processes of the self-regulated learner described above. Therefore, in this study, measured outcomes were based on the processes used by practising nurses to manage uncertainty, as observed by Cranley et al. (2012).

2.5 | Study purpose and research questions

The central purpose of this study was to determine if score-only feedback promotes self-regulatory patterns of learning compared with *knowledge of results* plus *elaborated feedback* (KR + EF) when completing formative online MCTs. We hypothesised that the uncertainty created by score-only feedback would place the onus on students to engage in self-regulatory learning activities as they completed formative MCTs. The following research questions (RQs) were addressed:

RQ1. What impact does score-only feedback have on metacognitive and cognitive engagement compared with KR + EF?

RQ2. What impact does score-only feedback have on behavioural engagement, including collaboration and information seeking, compared with KR + EF?

TABLE 1 Data sources.

	Participants ($N = 1082$)	RQ1: Metacognition and cognition	RQ2: Collaboration and information seeking	RQ3: Satisfaction
Surveys	$n = 802$		x	x
Summative test scores	$n = 937$	x		
Discussion board	$n = 1082$	x	x	
Focus groups	$n = 45$	x	x	x

RQ3. How satisfied were students with score-only feedback compared with KR + EF?

3 | METHODS

3.1 | Overview

This was a convergent, mixed methods study; a design described by Creswell and Clark (2017). As part of their completion of two subjects—Nursing Practice 1 (NP1) and Nursing Practice 2 (NP2)—students were required to complete weekly online MCTs (described below). There was a total of 1082 students enrolled in the study. Four data sources were used to answer the research questions (Table 1). Ethics approval was gained from the Tasmanian Social Sciences Human Research Ethics Committee (H0016050).

3.2 | Participants, intervention, and learning context

Participants were 1st and 2nd year nursing students recruited from an Australian university across four campuses between 2016 and 2018. NP1 and NP2 prepared students for their respective clinical placements, covering various clinical nursing skills and knowledge such as infection control, manual handling, nutrition, patient hygiene, and patient deterioration. A series of formative online MCTs were implemented in both subjects. NP1 contained eight weekly MCTs, and NP2 contained five weekly MCTs. The MCTs were used to support a flipped classroom design (see Hughes et al. (2020) for a quiz implemented with similar intent).

The formative online MCTs were open for one week and tested students on subject readings and online activities. Each MCT closed immediately before the commencement of the weekly, face-to-face practice sessions, which covered the related content. Students in both groups were encouraged to collaborate, and an online discussion board was opened for students to discuss the MCT questions. No staff contributed posts to this discussion board.

Students had up to 10 attempts for each formative online MCT (within the week timeframe), encouraging a 'test-learn-retest' cycle. Each MCT consisted of 10 questions—targeting different levels of Bloom's taxonomy—which were drawn from a bank of approximately 20 questions. Thus, students received a different combination of questions on each attempt. There was no time limit for each MCT attempt.

After each MCT attempt, students would receive feedback immediately. The type of feedback was the independent variable in our study and was the only variation in how the formative online MCTs were delivered to different groups. Students assigned to KR + EF could see which questions were right or wrong (KR) and received further guiding information (EF). The form of EF typically resembled *topic-contingent* feedback. For example, in addition to knowing if their answer was correct, students were told where to find the answer or given hints on how to work the question out (see Buchanan (2000) for more information on topic-contingent feedback). For score-only feedback, students only received a score out of 10. Unlike KR + EF, score-only feedback did not tell students which answers were correct/incorrect or provide any further information.

The aggregate weighting of the formative online MCTs was 10% and 20% of the overall subject grades in NP1 and NP2, respectively. This method meant that each MCT was worth less than 2% in NP1 and 4% in NP2. Only the highest-scoring attempt for each MCT (within the week timeframe) contributed to the grade. After each weekly MCT closed, the opportunity to score marks expired and the answers were revealed (regardless of the feedback type initially received).

As part of their assessment structure, each subject also had a practical exam and a summative, invigilated paper-based test. The questions in these closed-book summative tests assessed inferred knowledge from the online MCTs. They were vignette-based and single-best-answer questions aimed at testing higher-order cognition. These summative test scores were compared between groups as part of this study.

3.3 | Study design

3.3.1 | Quantitative data

The quantitative arm of this mixed methods study followed a quasi-experimental design. Data were collected from two cohorts. Students completing NP1 in 2016 (Group A) received *score-only* feedback on the completion of each formative online MCT attempt. Students completing NP1 in 2017 (Group B) received KR + EF. This difference aside, the delivery, content, and assessment structure of NP1 were the same in 2016 and 2017. Summative test scores, survey responses and the number of discussion board posts were compared between groups.

A crossover design was used for summative test scores and discussion board posts to mitigate the potential impact of sampling-error confounding induced by non-randomisation. Feedback types were flipped between each subject. Group A received KR + EF for NP2 MCTs, which they completed in 2017. Group B received score-only feedback for NP2 MCTs, which they completed in 2018. See Table 2. Feedback type aside, the delivery, content, and assessment structure of NP2 were the same in 2017 and 2018.

3.4 | Qualitative data

A descriptive design was used as the overarching approach to the qualitative arm of this mixed methods study. Data collected from focus groups and discussion board posts were used to gain insight into how students engaged in learning (metacognitively, cognitively, and behaviourally) when receiving different types of MCT feedback. Focus-group data were also used to better understand participants' satisfaction with the different feedback conditions.

3.5 | Recruitment and data collection

3.5.1 | Surveys

For the completion of surveys, all students ($N = 1082$) from Group A and B enrolled in NP1 (1st year) were invited to participate. Of these, 802 participated in the study by completing the survey, representing 74% of the cohort. There were no significant differences between Group A and Group B participating students in terms of age, English as an additional language, and campus of study. There was a significantly greater proportion of females in Group A ($p = 0.03$). Owing to logistical challenges, survey data were not collected for either group completing NP2.

Participants were recruited through convenience sampling, with surveys distributed after the final NP1 class by staff not involved in the study. Surveys consisted of 5-point Likert-type scales ('Strongly disagree' to 'Strongly agree') asking students to rate their agreement with statements on the extent to which they engaged in behavioural SRL strategies of information seeking and collaboration. Students were also asked to rate their satisfaction with the online MCTs.

TABLE 2 Crossover design.

	Group A ($n = 501$)	Group B ($n = 436$)
Nursing Practice 1 (NP1)	Score-only feedback (2016)	KR + EF (2017)
Nursing Practice 2 (NP2)	KR + EF (2017)	Score-only feedback (2018)

3.5.2 | Summative test scores

For comparison of summative test scores, only students who completed both NP1 and NP2 in consecutive years were included in the analysis ($n = 937$). The scores of students who repeated NP1 or did not complete both subjects were excluded. There was no significant difference in demographics between Group A and Group B (Table 3).

3.5.3 | Focus groups

Participants were recruited for the focus groups using purposive sampling through online noticeboards and lecture announcements. The target participant size for each focus group was 6–10. Focus groups were semi-structured and facilitated by researchers AS, CK and RS. Themes explored included metacognitive, cognitive, and behavioural engagement, as well as satisfaction and motivation. Forty-five students from both groups participated in six focus groups: four included participants from Group A, and two included participants from Group B. The focus groups were conducted when participants had completed NP1 and commenced NP2. At least one focus group was conducted on each of the four campuses. The average age of focus-group participants was 34.7 years old (SD = 9.85), 80% were female, and 40% spoke English as a second language.

3.5.4 | Discussion boards

Data were also collected from online discussion boards, where students were encouraged to collaborate while completing the formative online MCTs. All enrolled students ($N = 1082$) had access to the discussion boards in their respective units. Discussion board data were used to compare the frequency of student activity under each feedback condition and provided illustrative examples of how students engaged with the content and supported each other.

3.6 | Data analysis

Unpaired *t* tests compared between-group summative test scores of NP1 and NP2. A crossover design was used to compare summative test scores. Carryover and treatment effects were assessed using *t* tests. Normality assumptions were tested for parametric tests. The survey responses were analysed using Wilcoxon signed-rank tests. Analyses were performed in R Studio (version 3.6.0) and Excel (version 16.0) using a 0.05 decision level. Discussion board data, used to measure cognitive and behavioural learning patterns, were quantified using deductive content analysis and reported descriptively to compare group activity.

Qualitative data from the focus groups were analysed using thematic analysis. NVivo (version 12) was used to sort data into four a priori themes. These themes were based on the research question, which included the cognitive, metacognitive (RQ1), and behavioural

(RQ2) domains of SRL theory, as well as satisfaction (RQ3). See Table A1 for the code manual used. Content analysis was used to sort qualitative discussion board data with the intent to present illustrations of the students' discussions.

4 | RESULTS

4.1 | RQ1: Metacognitive and cognitive engagement

Students who received score-only feedback when completing formative online MCTs performed better in their summative assessment than those who received KR + EF. In NP1, the mean summative assessment score (57.64) of Group A, who received score-only feedback, was significantly higher than Group B (54.21), who received KR + EF feedback for their formative online MCTs ($p < 0.01$).

For the crossover experiment observing NP2, the mean summative assessment score (62.77) of Group B—who received score-only feedback—was significantly higher than the mean summative assessment score (56.27) of Group A, who received KR + EF feedback ($p < 0.01$) (Table 4).

For the crossover experiment, the score-only feedback condition had a positive treatment effect over the KR + EF condition (MD = 5.01, $p < 0.01$). The carryover effect was not significantly different between groups ($p = 0.08$). The treatment effect was observed between groups at each time point.

Qualitative data from the discussion board supported these findings. When students received score-only feedback, they asked probing questions and provided lengthy dialogic, generative feedback—reflective of higher-level cognition. When students received KR + EF feedback, the posts were more transmissive with surface-level questions and answers (i.e., identifying the correct response to a question with no explanation). For example,

> *It ended up being C—but not before I got it wrong the first time!*

Data from the focus groups suggested that students who received score-only feedback were more likely to engage higher-level cognition while completing the MCTs than those who received KR + EF.

> *With feedback [KR+EF], I just looked into my phone … There's no reasoning or understanding. But without feedback [score-only], it's more about the reasoning and understanding which helped me.*

> *With [KR+EF] feedback, we can study and apply trial-and-error to score the marks. It wasn't necessary to have the deep knowledge. But without feedback [score-only] it is deeper.*

Data from the focus group also suggested greater metacognitive activation when students were given score-only feedback. In particular, their evaluation of their performance after each MCT.

> *[With score-only feedback] if you're not sure about a question, and why the answer is wrong, you have to look for it more. Like, I'm pretty sure the answer to number*

TABLE 4 Summative test scores of students in NP1 and NP2.

	Group A	Group B	*p* value
Nursing Practice 1	2016 score-only	2017 KR + EF	
Enrolled students	($n = 501$)	($n = 436$)	
Assessment task (%)	57.64 (15.6)	54.21 (14.74)	<0.001
Nursing Practice 2	2017 KR + EF	2018 score-only	
Enrolled students	($n = 501$)	($n = 436$)	
Assessment task (%)	56.27 (15.14)	62.77 (14.46)	<0.001

TABLE 3 Characteristics of crossover cohort.

	Group A ($n = 501$)	Group B ($n = 436$)	*p* value
Number of students	501	436	
Study entry age (years)	27.62 (9)	27.23 (7.82)	0.48
Female (%)	82.04	76.83	0.06
English as a second language (%)	26.35	30.73	0.15
Campus (%)			
Darlinghurst	9.98	12.84	0.20
Hobart	26.55	25.46	
Launceston	39.72	42.66	
Rozelle	23.75	19.04	

Note: Includes only students who completed both NP1 and NP2, and excludes any repeating students. All values are described as mean (SD), except where a percentage value is used. Percentages are representative of the respective sub-group. χ^2 or *t* tests were used to determine *p* values.

one is right, but question number two I'm not 100% sure this is right, so I could look for the reasoning why my answer is not right.

4.2 | RQ2: Behavioural engagement

4.2.1 | Collaboration

Self-reporting data from the surveys indicated that there was no significant difference in collaborative activities when analysed using Wilcoxon signed ranks test ($p = 0.22$) (Table 5).

TABLE 5 Survey responses: Nursing Practice 1.

	Group A 2016 ($n = 429$)	Group B 2017 ($n = 373$)	
	Score-only feedback	KR + EF feedback	Wilcox score (p value)
Satisfaction	3.61 (0.96)	4.02 (0.8)	0.001
Textbooks/ resources	4.08 (0.9)	4.19 (0.79)	0.14
Collaboration	2.41 (1.19)	2.5 (1.15)	0.21

Discussion board data did not support these findings (Figure 1). There were substantially more topic-related NP1 discussion board posts when students received score-only feedback ($n = 88$) compared with KR + EF ($n = 11$). Similarly, there were more NP2 discussion board posts when students received score-only feedback ($n = 68$) compared with KR + EF ($n = 4$).

Data from the focus group highlighted different types of collaboration, dependent on feedback received. When score-only feedback was received, students reported generative dialogue and collaboration:

> *What's even better is when you disagree and you say 'no this is not right', then that's a discussion, then you look for the answer.*

When students received KR + EF feedback, they engaged in more transmissive, surface-level dialogue.

> *With [KR+EF] feedback, you know if it's correct or not, so you can just take a picture with the phone and just pass it on to everybody else … so there was no discussion. With [score-only] feedback it's different because you can't see which one is wrong, so you have to work it out.*

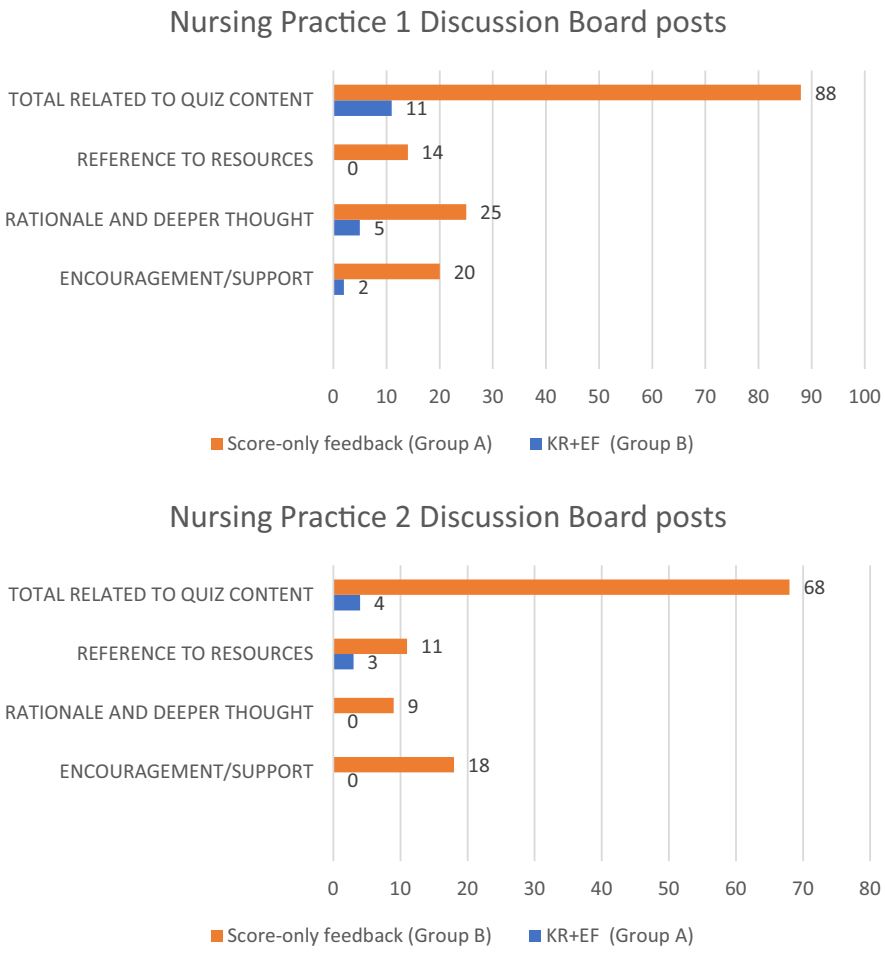

FIGURE 1 The number of discussion board posts.

4.2.2 | Information seeking

Quantitative data from surveys indicated no significant difference between self-reported information-seeking between Group A and Group B ($p = 0.14$) (Table 5).

Discussion board data did not support these findings. When receiving score-only feedback, students were more likely to share or direct their peers to relevant sources of information (such as government guidelines and evidence-based literature).

Data from the focus groups indicated that students were more likely to discuss the questions with clinical nurses and doctors not affiliated with the University when score-only feedback was received.

> *I asked the nurses [while on clinical placement], and the nurses had this debate about it and they were: 'no, it's not like this, it's like that'. Even they couldn't work it out! And eventually they agreed on a consensus. I know that's probably cheating.*

4.3 | RQ3: Satisfaction

Data from surveys and focus groups indicated that participants who received score-only feedback were less satisfied than those receiving KR + EF ($p < 0.01$).

Qualitative data from the focus groups broadly supported these findings.

> *You can't learn from your mistakes if you don't know what your mistakes are.*

> *And the problem is you never know what you're getting wrong. That means you walk away, and you might get to 80% and have put five hours into it and you finally give up … and you don't know what you've got wrong.*

5 | DISCUSSION

To our knowledge, this is the first study testing the effectiveness of score-only feedback for formative online MCTs in a real-life setting. The results from this study indicate that students receiving score-only feedback were more likely to use metacognitive, cognitive, and behavioural strategies to resolve uncertainty. Students receiving verification and elaborated feedback (KR + EF), on the other hand, could rely wholly on feedback provided by the online MCT to identify correct answers—often bringing premature closure to valuable learning opportunities.

5.1 | Metacognitive and cognitive engagement

In this study, all data indicated that students were more cognitively engaged in their learning when receiving score-only feedback. For both subjects (NP1 and NP2), students who received score-only feedback performed better in the summative tests, which were designed to test mid- to higher-order learning. Focus-group data revealed that score-only feedback was associated with a need to self-evaluate, understand and engage more deeply. Finally, discussion board data revealed extensive dialogue between students—explaining concepts and interrogating each other's rationale—under the score-only condition. When KR + EF was received, discussion board activity was minimal, and posts were devoid of discussion or rationale for answers.

It is widely recognised in work-readiness literature that graduates must possess higher-order cognitive skills, including problem solving and critical thinking. This is notably pertinent to nurse education, where cognitive capabilities including critical thinking, clinical reasoning, and decision making, are frequently used by nurses to navigate uncertain, complex practice contexts (Christiansen et al., 2018; Cranley et al., 2012; Kuiper & Pesut, 2004). However, the ability of nurses to make crucial decisions that impact patient outcomes is often undermined by inadequate cognitive skills (Andreou et al., 2014; Thompson & Yang, 2009).

Similarly, metacognitive skills such as reflection and the ability to self-assess performance are vital nursing capabilities (Kuiper et al., 2010; Parker et al., 2014). The ability to evaluate or assess one's current performance and differentiate this between desired performance is a sine qua non to further self-regulatory actions (Pintrich & Zusho, 2002). Without recognising performance gaps, the learner is dependent on external sources to improve performance and, thus, is not autonomous. Nurses require the ability to autonomously evaluate knowledge, and the experience to recognise uncertainty and take appropriate remedial action (Cranley et al., 2012). Nevertheless, Thompson and Yang (2009) observed that, regardless of experience, nurses tend to have difficulty calibrating confidence to assess the correctness of their actions. These critical cognitive and metacognitive activities can be developed through educational programs (Kuiper & Pesut, 2004; Thompson & Yang, 2009), as evidenced in this study's focus groups:

> *Before [with KR+EF], when we used to score 9/10, I wouldn't look at the nine [correct] questions. But now [with score-only feedback] I have to go through all the questions and answers again, and again, and again until I get it right …*

The above quote is illustrative of data that pointed to the deleterious impact of KR + EF on metacognition. The tendency of students to ignore feedback on questions identified as correct, as is the case for KR + EF, has been noted elsewhere (van der Kleij et al., 2012) and could be attributable to poor metacognitive calibration. The inclination to overestimate knowledge and have false confidence in incorrectly answered questions has been widely reported (see von Hoyer et al. (2022) for a discussion and study on this effect). Thus, when receiving KR + EF, not only are students told when they are wrong, but there is no need to interrogate levels of understanding for correct responses—which can represent anything from a complete guess to thorough comprehension when completing multiple-choice questions

(Mason & Bruning, 2001). However, when receiving score-only feedback, students had to evaluate the plausibility of every answer if they wanted to improve in subsequent attempts.

Data were also suggestive that KR + EF required less cognitive engagement. Formative feedback for most learning activities guides students on a continuum towards a more correct answer. Formative online MCT feedback, on the other hand, identifies answers as entirely correct or incorrect—a binary outcome near exclusive to multiple-choice-type questions. Through the selection of predetermined answers, the active construction of knowledge is limited (Nicol, 2007), with no requirement for dialogue or opportunity to construct a unique understanding of the problem. Thus, the learner can 'short-circuit' the learning process by systematically narrowing down the remaining options on repeated attempts through trial-and-error learning (Morrison et al., 1995)—a process evident from the qualitative data collected in this study. In reference to multiple-choice questions, Clariana and Koul (2005) caution against overly instructive feedback, which can result in a focus on the 'question—correct response' association. This superficial approach to learning overlooks the deeper processing required to understand the complex reasons behind why a particular response is correct (Draper, 2009). Score-only feedback, on the other hand, creates uncertainty requiring students to internalise feedback and construct understanding—a more authentic representation of how formative feedback should trigger corrective cognitive processes (Nicol & Macfarlane-Dick, 2006).

Encouraging SRL strategies in education settings, as evidenced in this study, plays a crucial role in developing the cognitive skills required of many professions, including nursing (Kuiper & Pesut, 2004), and maintaining uncertainty is an important element of capability-oriented education (O'Connell et al., 2014). Therefore, judicious formative feedback approaches are required to prompt higher-order cognitive processes in the completion of MCTs. Where these internal cognitive processes cannot sufficiently resolve uncertainty, the onus is on the student to decide when and how they will supplement their reasoning with further information from external sources.

5.2 | Behavioural engagement

Participants in this study who received score-only feedback were more likely to engage in collaborative activities and information seeking to resolve uncertainty. Participants who received KR + EF, on the other hand, were provided with certainty on completion of their MCT and were able to score full marks through trial-and-error learning.

5.2.1 | Collaboration

While self-reported data in surveys did not show any significant difference in how participants collaborated under the two types of feedback, discussion board data identified that students receiving score-only feedback engaged in more collaborative discussions than those who received KR + EF. Data from focus groups indicated that participants were more likely to engage in constructivist interactions when receiving score-only feedback, as opposed to transmissive information exchange when receiving KR + EF.

The evidence of autonomous, voluntary collaboration facilitated by score-only feedback is an important finding. It highlights the vital role uncertainty plays in generating constructivist discussions. While causal links were not established in this study, discussion board activity positively correlated with higher summative test scores and qualitative data revealed examples of richer, dialogic exchanges when score-only feedback was provided. The results also add weight to the argument that students should be encouraged to collaborate in the completion of formative online MCTs. Given the frequent citing of student collusion and cheating in the context of online MCTs (Sullivan, 2016; Wideman, 2011; Woeste & Barham, 2008), it is understandable that educators may be hesitant to encourage peer collaboration. However, the power of peer feedback to elicit deeper learning is widely accepted in formative assessment and SRL literature (Clark, 2012; Nicol & Macfarlane-Dick, 2006). Thus, if the primary purpose of online MCTs is learning, then peer collaboration should be considered a valuable outcome.

5.2.2 | Information seeking

Evidence of information seeking as an outcome of feedback type was less conclusive. Self-reporting surveys showed no difference in information-seeking patterns between feedback types. Surface-level information-seeking strategies were described in the focus group for both feedback types. One common approach was using the search function in digital documents to locate key, question-related words—a behaviour reported elsewhere in online quiz literature (Cook & Babon, 2017). Such information-seeking behaviour is synonymous with what Pintrich (2000) called maladaptive help-seeking, where the student is more intent on 'seeking a correct answer without much work' (p. 468).

However, when score-only feedback was provided, the discussion board showed a higher frequency of references to evidence-based information from online sources. This finding is notable given the challenges students have seeking out reliable sources of information, and evidence that online information-seeking activities can result in misplaced confidence in acquired knowledge (von Hoyer et al., 2022). The fact that students in the current study were sourcing reliable information and discussing their interpretation of this information with peers is a positive outcome related to score-only feedback. Additionally, patterns of deeper searching, including seeking assistance from clinicians, were more evident in the score-only group. These learner activities were suggestive of a desire for a deeper understanding of content, described by Pintrich (2000) as adaptive help-seeking.

Uncertainty underpins the extent and variety of information-seeking behaviours in nurses (O'leary & Mhaolrúnaigh, 2012). However, Thompson and Yang (2009) noted a tendency for nurses, when facing uncertainty, to forego evidence-based sources in favour of intuition—which is prone to bias and poor decision-making. To

address this trend, they suggest more emphasis on learning activities characterised by uncertainty. It has been long speculated that learners who receive less feedback in computer-based learning are more likely to seek out information (Buchanan, 2000; Cook & Babon, 2017; Pridemore & Klein, 1995). This study supports this sentiment insofar that a greater variety of adaptive information-seeking was evident when states of uncertainty, elicited by score-only feedback, existed.

5.3 | Satisfaction

Participants in this study were more satisfied with the MCTs when KR + EF was provided. Participants reported frustration with score-only feedback and the lack of direction or clarity it gave, which appeared to negatively affect motivation levels for some students. This finding is consistent with commentary on the importance of feedback to, at the very least, verify the correctness of responses. As asserted by Mory (2004), 'If feedback is to serve a corrective function, even in its most simple form feedback should verify whether the student's answer is right or wrong' (p. 29). Similarly, students in a study by van der Kleij et al. (2012) reported a preference for more directive feedback in the form of KCR + EF rather than KR alone. In the current study, frustration with score-only feedback caused some students to disengage, something Jaehnig and Miller (2007) caution against with computer-based learning design.

However, the results on satisfaction stand in contrast with positive cognitive, metacognitive and behavioural outcomes, and there were still participants who spoke positively of the score-only approach, appreciating the challenge it presented and the subsequent deeper learning that occurred:

> *But also, those questions where you research the hell out of them, and you go 'I know this is right' and that's going to stick in your head too. You're not going to forget it. If that question comes up in an exam, you'll go 'I know the answer to this because I got stuck on that for three days.'*

This statement reflected several comments that participants made during focus groups, demonstrating great clarity of recall (a significant time after the event) when describing 'frustrating' questions. Focus-group data reaffirmed anecdotal evidence that students engage in classroom discussions on questions with great depth and insight from a position of frustration. Students felt they did not have the 'correct' answer, but their understanding of concepts underpinning the answer—their ability to reason—was very strong.

Some strategies may ease student frustration and improve satisfaction, while maintaining the benefits of uncertainty when receiving score-only feedback. Firstly, addressing the expectations of students and providing ample rationale for the approach may have seen improvements in satisfaction scores. The importance of focusing on the process of learning (*how* to learn) to prepare nursing students for complex and ever-expanding discipline knowledge has been long recognised. As Sadler (1998) argued, the ultimate 'intention of most educational systems is to help students not only grow in knowledge and expertise, but also to become progressively independent of the teacher for lifelong learning' (p. 82). Thus, the importance of learning processes, not just *what* is being learnt, must be continually reinforced with students.

Supporting students to adjust their expectations can be challenging. Sadler (1998) referred to the 'temporal conditioning' of students exposed to particular ways of teaching, and the time it takes to reverse students' expectations of a teaching environment. Sharples and Moseley (2011) concluded in a study on self-directed learning that a level of disengagement may have been attributable to an overemphasis on content at the expense of providing the rationale behind the learning activity. Participants in our study expressed similar sentiments of disengagement when students felt that MCT designers had not considered their learning needs. Mazur (1997) noted students' 'deeply ingrained' expectations of teachers in terms of transmissive teaching, and the effort it takes to shift these expectations. This observation is pertinent to the online MCTs discussed here. Participants expressed dissatisfaction with score-only feedback by referencing their experience with other online MCTs for which they received verification (KR) feedback.

The second determinant of satisfaction with score-only feedback may relate to how advanced students are in the course. It has been argued that feedback works best when students have a basic understanding of concepts. Where foundational knowledge is lacking, instruction rather than feedback may be more appropriate (Hattie & Timperley, 2007; Sadler, 2010). This point was supported by Winne (1995), who suggested that where conditional knowledge is markedly lacking, attempts by students to self-regulate can be detrimental to learning. Rather, students should allocate cognitive resources to building domain knowledge. Thus, score-only feedback may be better suited to more senior students with greater discipline knowledge to draw on. This conclusion is consistent with literature on computer-based learning, which indicates that less directive item-based feedback may be beneficial when targeting higher learning outcomes for students with a more extensive knowledge base (Mason & Bruning, 2001; van der Kleij et al., 2015).

Finally, while students were less satisfied with score-only feedback in this study, it is likely dissatisfaction would have been amplified had peer collaboration not been facilitated and encouraged. The premise of the approach described in this paper is not that less feedback is better, but rather that less teacher-centric feedback drives students to richer sources of information, such as peer dialogue. Data in this study not only indicated that students benefited from peer feedback, but also that peer feedback was highly valued. Kibble et al. (2011) asserted that enhanced learning outcomes would be achieved with online MCTs where students are provided with structured support to be self-regulated learners. In this study, structured supports were evident in the establishment of a devoted online discussion board to discuss online MCT questions and the active promotion of peer learning by faculty.

5.4 | Limitations

Educational interventions can be complex and challenging to measure due to numerous confounding factors (Wilkes & Bligh, 1999). The quasi-experimental design used in this study was prone to sampling error confounding due to non-randomisation of participants. Randomisation was not feasible as participants worked closely with each other and, given that students were encouraged to collaborate, any attempt to randomly allocate students would likely have seen contamination, with the control group (KR + EF) sharing answers with the experiment group (score-only feedback). Mitigation strategies for sampling error included normative group equivalence testing and a crossover design. However, students were not surveyed on the completion of NP2 (owing to limited accessibility), and thus the survey data were not included in crossover observations.

The current study was performed using a cohort of undergraduate nursing students, which may limit the generalisability to other cohorts and areas of study. However, given the ubiquity of online MCTs in higher education, the paucity of previous studies on score-only feedback, and the broad applicability of self-regulation as a metric for graduate work readiness, the current study provides evidence for the benefits of the score-only approach regardless of setting and discipline.

Finally, the survey was designed to address specific questions but was not validated. There was a stark difference between the self-reported behaviours of collaboration and information seeking in the survey, and data from the focus groups and discussion boards. This discrepancy can be partially accounted for by adaptive and maladaptive information-seeking approaches already discussed. However, it is unclear why there was a discrepancy between self-reported collaboration and evidence of actual collaboration.

6 | CONCLUSIONS

This study revealed that a score-only feedback approach for formative online MCTs is more likely to promote SRL patterns for students than a more standard approach of KR + EF. Students respond to the uncertainty triggered when no verification is received by self-evaluating their work, engaging higher-order cognition, and seeking help from their peers, clinicians and evidence-based sources. Nevertheless, score-only feedback was associated with decreased satisfaction, which appeared to impact motivation. Student dissatisfaction may be alleviated by providing more information about the rationale of score-only feedback, using this type of feedback for more advanced students, and encouraging peer collaboration in completing online MCTs.

This study is unique in its consideration of a novel, rarely-reported score-only feedback approach. The findings of this study find congruence with the two examples located in literature. The contrasting patterns of reference to key sources of information on the discussion board support Cook and Babon's (2017) untested premise that score-only feedback encourages more meaningful engagement with learning materials. The improved performance in summative assessments by students receiving score-only feedback built on findings by Anderson and McDaniel (2021), where there was no difference between summative scores of students receiving score-only feedback compared with verification feedback. Feedback containing higher volumes of information is generally considered more effective (Wisniewski et al., 2020). However, the findings of this study challenge long-standing assumptions that score-only feedback is an inferior approach to verification and elaborated feedback in formative online MCTs. Future research on this feedback approach should consider how other variables, such as the characteristics of learners, grading, and timing of quizzes, impact student engagement with online MCTs.

The broader implications of these findings should not be overlooked. Nursing is not unique as a profession in which individuals need to appraise their current performance and problem solve through cognitive and behavioural processes. Employers are increasingly seeking graduates who can think deeply about problems and seek out external feedback to test and expand their thought processes through collaboration and information seeking. The onus is on higher education providers to avoid an over reliance on transmissive forms of feedback and consider using feedback that allows for extended states of uncertainty, replicating the challenges of real-world workplaces.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ACKNOWLEDGMENT

Open access publishing facilitated by University of Tasmania, as part of the Wiley - University of Tasmania agreement via the Council of Australian University Librarians.

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/jcal.12868.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Richard Say https://orcid.org/0000-0002-8586-9703
Denis Visentin https://orcid.org/0000-0001-9961-4384

REFERENCES

Anderson, F. T., & McDaniel, M. A. (2021). Restudying with the quiz in hand: When correct-answer feedback is no better than minimal feedback. *Journal of Applied Research in Memory and Cognition*, *10*, 278–288.

Andreou, C., Papastavrou, E., & Merkouris, A. (2014). Learning styles and critical thinking relationship in baccalaureate nursing education: A systematic review. *Nurse Education Today*, *34*(3), 362–371.

Bennett, D., & Ananthram, S. (2022). Development, validation and deployment of the EmployABILITY scale. *Studies in Higher Education*, *47*(7), 1311–1325.

Boud, D., & Molloy, E. (2013). Rethinking models of feedback for learning: The challenge of design. *Assessment & Evaluation in Higher Education*, *38*(6), 698–712.

Bromley, P. (2017). From competence to capability. *Australian Nursing and Midwifery Journal*, *25*(2), 34.

Buchanan, T. (2000). The efficacy of a world-wide web mediated formative assessment. *Journal of Computer Assisted Learning*, *16*(3), 193–200.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research*, *65*(3), 245–281.

Candel, C., Máñez, I., Cerdán, R., & Vidal-Abarca, E. (2021). Delaying elaborated feedback within computer-based learning environments: The role of summative and question-based feedback. *Journal of Computer Assisted Learning*, *37*, 1015–1029.

Carpenter, S. K., Witherby, A. E., & Tauber, S. K. (2020). On students'(mis) judgments of learning and teaching effectiveness. *Journal of Applied Research in Memory and Cognition*, *9*(2), 137–151.

Christiansen, A., Jacob, E., & Twigg, D. (2018). Is it time to consider a four year nursing bachelor degree in Australia? A discussion paper. *Collegian*, *25*(5), 567–571.

Clariana, R. B., & Koul, R. (2005). Multiple-try feedback and higher-order learning outcomes. *International Journal of Instructional Media*, *32*(3), 239–245.

Clark, I. (2012). Formative assessment: Assessment is for self-regulated learning. *Educational Psychology Review*, *24*(2), 205–249.

Coetzee, M. (2014). Measuring student graduateness: Reliability and construct validity of the graduate skills and attributes scale. *Higher Education Research and Development*, *33*(5), 887–902.

Cook, B. R., & Babon, A. (2017). Active learning through online quizzes: Better learning and less (busy) work. *Journal of Geography in Higher Education*, *41*(1), 24–38.

Cranley, L. A., Doran, D. M., Tourangeau, A. E., Kushniruk, A., & Nagle, L. (2012). Recognizing and responding to uncertainty: A grounded theory of nurses' uncertainty. *Worldviews on Evidence-Based Nursing*, *9*(3), 149–158.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Sage Publications.

Deci, E. L., & Ryan, R. M. (2008). Facilitating optimal motivation and psychological well-being across life's domains. *Canadian Psychology/Psychologie Canadienne*, *49*(1), 14–23.

Draper, S. W. (2009). Catalytic assessment: Understanding how MCQs and EVS can foster deep learning. *British Journal of Educational Technology*, *40*(2), 285–293.

Einig, S. (2013). Supporting students' learning: The use of formative online assessments. *Accounting Education*, *22*(5), 425–444.

Fernandez-Duque, D., Baird, J. A., & Posner, M. I. (2000). Executive attention and metacognitive regulation. *Consciousness and Cognition*, *9*(2), 288–307.

Hao, Q., Smith, D. H., IV, Ding, L., Ko, A., Ottaway, C., Wilson, J., Arakawa, K. H., Turcan, A., Poehlman, T., & Greer, T. (2022). Towards understanding the effective design of automated formative feedback for programming assignments. *Computer Science Education*, *32*(1), 105–127.

Harrison, H., Birks, M., Franklin, R., & Mills, J. (2019). An assessment continuum: How healthcare professionals define and determine practice readiness of newly graduated registered nurses. *Collegian*, *27*, 198–206.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, *77*(1), 81–112.

Hughes, M., Salamonson, Y., & Metcalfe, L. (2020). Student engagement using multiple-attempt 'weekly participation Task'quizzes with undergraduate nursing students. *Nurse Education in Practice*, *46*, 1–6.

Jaehnig, W., & Miller, M. L. (2007). Feedback types in programmed instruction: A systematic review. *The Psychological Record*, *57*(2), 219–232.

Kibble, J. D., Johnson, T. R., Khalil, M. K., Nelson, L. D., Riggs, G. H., Borrero, J. L., & Payer, A. F. (2011). Insights gained from the analysis of performance and participation in online formative assessment. *Teaching and Learning in Medicine*, *23*(2), 125–129.

Kuiper, R., Murdock, N., & Grant, N. (2010). Thinking strategies of baccalaureate nursing students prompted by self-regulated learning strategies. *Journal of Nursing Education*, *49*(8), 429–436.

Kuiper, R. A., & Pesut, D. J. (2004). Promoting cognitive and metacognitive reflective reasoning skills in nursing practice: Self-regulated learning theory. *Journal of Advanced Nursing*, *45*(4), 381–391.

Kuklick, L., & Lindner, M. A. (2021). Computer-based knowledge of results feedback in different delivery modes: Effects on performance, motivation, and achievement emotions. *Contemporary Educational Psychology*, *67*, 102001.

Limniou, M., & Smith, M. (2014). The role of feedback in e-assessments for engineering education. *Education and Information Technologies*, *19*(1), 209–225.

Lin, C.-C., Han, C.-Y., Pan, I.-J., & Lin, P.-L. (2016). Exploring the perceptions of core values of nursing in Taiwanese nursing students at the baccalaureate level. *Journal of Nursing Research*, *24*(2), 126–136.

Mason, B., & Bruning, R. (2001). Providing feedback in computer-based instruction: What the research tells us. https://www.researchgate.net/publication/247291218_Providing_Feedback_in_Computer-based_Instruction_What_the_Research_Tells_Us

Mazur, E. (1997). Peer instruction: Getting students to think in class. Paper presented at the AIP Conference Proceedings.

McNulty, J. A., Espiritu, B. R., Hoyt, A. E., Ensminger, D. C., & Chandrasekhar, A. J. (2015). Associations between formative practice quizzes and summative examination outcomes in a medical anatomy course. *Anatomical Sciences Education*, *8*(1), 37–44.

Morris, R., Perry, T., & Wardle, L. (2021). Formative assessment and feedback for learning in higher education: A systematic review. *The Review of Education*, *9*(3), e3292.

Morrison, G. R., Ross, S. M., Gopalakrishnan, M., & Casey, J. (1995). The effects of feedback and incentives on achievement in computer-based instruction. *Contemporary Educational Psychology*, *20*(1), 32–50.

Mory, E. H. (2004). Feedback research revisited. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology* (Vol. 2, pp. 745–783). Lawrence Erlbaum Associates Publishers.

Nicol, D. (2007). E-assessment by design: Using multiple-choice tests to good effect. *Journal of Further and Higher Education*, *31*(1), 53–64.

Nicol, D., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, *31*(2), 199–218.

O'Connell, J., Gardner, G., & Coyer, F. (2014). Beyond competencies: Using a capability framework in developing practice standards for advanced practice nursing. *Journal of Advanced Nursing*, *70*(12), 2728–2735.

O'leary, D. F., & Mhaolrúnaigh, S. N. (2012). Information-seeking behaviour of nurses: Where is information sought and what processes are followed? *Journal of Advanced Nursing*, *68*(2), 379–390.

Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology*, *8*, 422.

Parker, V., Giles, M., Lantry, G., & McMillan, M. (2014). New graduate nurses' experiences in their first year of practice. *Nurse Education Today*, *34*(1), 150–156.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In *Handbook of self-regulation* (pp. 451–502). Elsevier.

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review*, *16*(4), 385–407.

Pintrich, P. R., & Zusho, A. (2002). Student motivation and self-regulated learning in the college classroom. In J. C. Smart & W. G. Tierney (Eds.), *Higher education: Handbook of theory and research* (Vol. 17). Agathon Press.

Pridemore, D. R., & Klein, J. D. (1995). Control of practice and level of feedback in computer-based instruction. *Contemporary Educational Psychology*, *20*(4), 444–450.

Reime, M. H., Harris, A., Aksnes, J., & Mikkelsen, J. (2008). The most successful method in teaching nursing students infection control—E-learning or lecture? *Nurse Education Today*, *28*(7), 798–806.

Roberts, D. (2006). Learning experiences of seconded pre-registration nursing students. *Nursing Standard*, *20*(36), 41–45.

Sadler, D. R. (1998). Formative assessment: Revisiting the territory. *Assessment in Education: Principles, Policy & Practice*, *5*(1), 77–84.

Sadler, D. R. (2010). Beyond feedback: Developing student capability in complex appraisal. *Assessment & Evaluation in Higher Education*, *35*(5), 535–550.

Say, R., Visentin, D., Cummings, E., Carr, A., & King, C. (2022). Formative online multiple-choice tests in nurse education: An integrative review. *Nurse Education in Practice*, *58*, 103262.

Sharples, K., & Moseley, L. G. (2011). Learning to learn self-regulation in practice: A 2 cohort evaluation. *Nurse Education in Practice*, *11*(6), 345–350.

Sinatra, G. M., Heddy, B. C., & Lombardi, D. (2015). *The challenges of defining and measuring student engagement in science* (Vol. 50, pp. 1–13). Taylor & Francis.

Sitzmann, T., & Ely, K. (2011). A meta-analysis of self-regulated learning in work-related training and educational attainment: What we know and where we need to go. *Psychological Bulletin*, *137*(3), 421–442.

Stephenson, J. (1992). Capability and quality in higher education. In J. Stephenson & S. Weil (Eds.), *Quality in learning*. Kogan Page.

Stephenson, J. (2013). The concept of capability and its importance in higher education. In J. Stephenson & M. Yorke (Eds.), *Capability and quality in higher education* (pp. 1–13). Routledge.

Sullivan, D. P. (2016). An integrated approach to preempt cheating on asynchronous, objective, online assessments in graduate business classes. *Online Learning*, *20*(3), 195–209.

Thompson, C., & Yang, H. (2009). Nurses' decisions, irreducible uncertainty and maximizing nurses' contribution to patient safety. *Healthcare Quarterly*, *12*, 178–185.

van der Kleij, F. M., Eggen, T. J., Timmers, C. F., & Veldkamp, B. P. (2012). Effects of feedback in a computer-based assessment for learning. *Computers & Education*, *58*(1), 263–272.

van der Kleij, F. M., Feskens, R. C., & Eggen, T. J. (2015). Effects of feedback in a computer-based learning environment on students' learning outcomes: A meta-analysis. *Review of Educational Research*, *85*(4), 475–511.

von Hoyer, J. F., Kimmerle, J., & Holtz, P. (2022). Acquisition of false certainty: Learners increase their confidence in the correctness of incorrect answers after online information search. *Journal of Computer Assisted Learning*, *38*(3), 833–844.

Wideman, M. (2011). Caring or collusion? Academic dishonesty in a school of nursing. *Canadian Journal of Higher Education*, *41*(2), 28–43.

Wilkes, M., & Bligh, J. (1999). Evaluating educational interventions. *BMJ*, *318*(7193), 1269–1272.

Wilson, K., Boyd, C., Chen, L., & Jamal, S. (2011). Improving student performance in a first-year geography course: Examining the importance of computer-assisted formative assessment. *Computers & Education*, *57*(2), 1493–1500.

Winne, P. H. (1995). Inherent details in self-regulated learning. *Educational Psychologist*, *30*(4), 173–187.

Winstone, N. E., Ajjawi, R., Dirkx, K., & Boud, D. (2022). Measuring what matters: The positioning of students in feedback processes within national student satisfaction surveys. *Studies in Higher Education*, *47*(7), 1524–1536.

Winterton, J., & Turner, J. J. (2019). Preparing graduates for work readiness: An overview and agenda. *Education+Training*, *61*(5), 536–551.

Wisniewski, B., Zierer, K., & Hattie, J. (2020). The power of feedback revisited: A meta-analysis of educational feedback research. *Frontiers in Psychology*, *10*, 3087.

Woeste, L. A., & Barham, B. J. (2008). Wake up! Your PDQ is due! *American Society for Clinical Laboratory Science*, *21*(1), 12–14.

Zimmerman, B. J. (1986). Becoming a self-regulated learner: Which are the key subprocesses? *Contemporary Educational Psychology*, *11*(4), 307–313.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice*, *41*(2), 64–70.

How to cite this article: Say, R., Visentin, D., Saunders, A., Atherton, I., Carr, A., & King, C. (2023). Where less is more: Limited feedback in formative online multiple-choice tests improves student self-regulation. *Journal of Computer Assisted Learning*, 1–15. https://doi.org/10.1111/jcal.12868

APPENDIX A

TABLE A1 Code manual for focus-group data

Code name	Research question	Definition	Example
Cognitive engagement	RQ1: Cognitive and metacognitive engagement.	Reflects levels of cognition engaged in the completion of the exercise. Participant describes the cognitive processes used to complete the online MCTs. This could include deeper engagement with material or superficial strategies, such as trial-and-error learning	*You try to understand what the question is about and why the answer would be what it is, rather than just passing and getting the marks.*
Metacognitive engagement	RQ1: Cognitive and metacognitive engagement.	Reflects metacognitive processes to enhance learning. Participant describes a process that specifically relates to evaluation of their work. Alternatively, the participant refers to an action that does not involve metacognitive engagement, such as guess work.	*Then you go through it again. I got that one right. I know that one's right! But really? Am I reading it wrong? Do I need to re-read it? And I think 'that one's definitely right'. And you do that with every single question. And by the end you're like 'so which ones did I actually get wrong?'*
Information seeking	RQ2: Behavioural engagement	Reflects autonomous regulation of behaviour to enhance learning. Participant describes an action of seeking out information to complete online MCTs. This can be from any source other than peers, which is categorised as *Collaboration*. Sources of information include texts, online resources, healthcare professionals in practice, or academics.	*You have to go onto MYLO, go through the content, go through all the lectures, readings. You can't escape because it's every week.*
Collaboration	RQ2: Behavioural engagement	Reflects autonomous regulation of behaviour to enhance learning. Participant describes an action of working with peers in some form to complete the online MCTs. This includes working on the quiz together, sharing answers, or engaging on the discussion board.	*And you work together, even though the answer will be the same. When you discuss it with a friend, they will tell you a different way to understand it and you'll remember it for a long time.*
Satisfaction	RQ3: Satisfaction	Relates to how satisfied students were with the online MCTs. Participants describe either their satisfaction or dissatisfaction with the feedback they received in the online MCTs.	*It might be something really important that you've got wrong, and you don't know what it is. So I remember getting a bit upset once where I thought, this is such fundamental nursing knowledge. I can't get this wrong. I need to understand this stuff.*