‘I just looked at the answers’: How the voluntary use of online quizzes impacts performance in introductory accounting.

Raechel Wight[a]*, James Wakefield[a], Peter Wells[a] and Jessica Frawley[b]

[a]*Accounting Discipline Group, University of Technology Sydney, Sydney, Australia;*
[b]*Educational Innovation Team, The University of Sydney, Sydney, Australia*

*corresponding author email: Raechel.Wight@uts.edu.au

University of Technology Sydney, PO Box 123, Broadway NSW 2007, Australia

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Purpose: The aim of this study is to investigate the effectiveness of how students voluntarily use online quizzes that are not multiple-choice questions (MCQs) to support learning of introductory accounting. In particular, whether using quizzes to self-test their current level of knowledge results in higher performance on the related exam question than using the quizzes to access the worked example solutions.

Design/methodology/approach: An ordinary least squares multiple regression model and piecewise regression model that controls for student characteristics associated with performance is used to examine the association between voluntary online quizzes and student performance. Self-selection bias is controlled for using both propensity score matching and by using the student as their own control, comparing their exam score between questions where they did or did not use the related online quiz.

Findings: Results indicated that using the quiz as a self-test and achieving a pass on the online quiz was the better strategy for learning to record journal entries, whereas using the quiz as a worked example was associated with exam performance for calculating adjusting entries, closing entries and the managerial accounting topics. However, clicking through to look at the answers is insufficient - students still need to actively complete the quiz to receive the benefit from using the quiz to access the worked example.

Research limitations/implications: In the absence of a fully randomised study, causation can not be attributed to the online quizzes and the association with performance. The study was conducted at one university in one year, limiting the generalizability of the findings.

Originality/value: The study contributes to the literature theoretically, by modifying and operationalising Biggs’ 3P model to show how it can be used as a theoretical framework to guide the choice of variables in the statistical modelling; methodologically, by aligning the level of analysis to consider the association between online quizzes and exam performance on the same topic rather than overall performance measure; and practically, providing evidence of the effectiveness of quizzes that are not MCQs, where the findings can be used to advise students on the most effective way to use quizzes to enhance their learning.

Keywords: formative assessment; online quiz; 3P model; self-regulation theory; testing effect; worked example

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Abstract

This study investigates the effectiveness of different way students use online quizzes to support learning of accounting. Students may use the quiz as a ‘self-test’ where they repeat the quiz until they pass, or as a ‘worked example’ to access the elaborate solutions provided in the quiz feedback. In a first year undergraduate accounting course, both use and performance on the quiz was associated with exam performance on the related exam topic for all topics. Results indicated that quiz performance is a more useful predictor of exam performance on the same topic than quiz use, demonstrating that the testing effect applies to introductory accounting. Using the quiz as a self-test rather than a worked example was the better strategy for learning to record journal entries, whereas using the quiz as a worked example was associated with exam performance for other topics. An important caveat is that when using the quizzes as a worked example, students still needed to make a genuine attempt to complete the quiz to receive the benefit. The results of this study add to the growing body of evidence that the voluntary use of online quizzes can help students access feedback to succeed in learning introductory accounting.

Keywords: formative assessment; online quiz; 3P model; self-regulation theory; testing effect; worked example

JEL classification: A22, I21, I23

Introduction

The aim of this paper is to evaluate the effectiveness of voluntary online quizzes to support learning in an introductory accounting subject. The online quizzes in the current study differ from prior accounting education research investigating online quizzes as they are not multiple choice questions (MCQs). Instead, the online quizzes under investigation are designed to mimic the process students are required to demonstrate in introductory accounting and are provided purely as a voluntary learning resource to students. Additionally, by evaluating the association between the online quiz and exam performance on the same topic, rather than overall exam performance used in prior studies, the current study accurately aligns the level of analysis, which may explain the inconsistent results in in prior research. Finally, this study investigates the different ways in which students may use the quiz, which has not been addressed by the literature. Students may have a deep approach to using the quiz as a 'self-test' where they repeatedly take the quiz until they pass the quiz and successfully demonstrate their knowledge of the topic. Alternately students may adopt a surface level approach to the quiz, using the quiz as a 'worked example' to access the elaborate solutions provided in the quiz feedback. The current study seeks to understand these different ways students can use the online quizzes, and whether the different ways they use these quizzes has a different magnitude of impact on their performance in introductory accounting.

While prior research has looked at the association between voluntary online MCQ quiz use and performance (Beatson et al., 2020; Einig, 2013; Massoudi et al., 2017; Ross et al., 2018), there are a number of limitations. First, they focus on MCQs and have not explored the different question formats that are readily available in learning management systems, formats that can be used to design quizzes that to more authentically replicate accounting processes, such as journal entries. Second, prior studies either investigated overall quiz use and overall exam performance,

whereas each quiz topic may have a different impact on performance, or they misaligned the level of analysis comparing individual quizzes to overall exam performance, where significant results are likely to occur only when the quiz topic comprises a large proportion of the exam. Additionally, prior studies do not consider the different ways students may use the quizzes, as a self-test or as a worked example, which creates significant endogeneity problems. This gap in the literature leads us to the first research question, how does the way in which the student uses the formative online quizzes impact on their performance in different topics introductory accounting?

Many interventions designed to enhance student learning can show some evidence of success (Hattie, 2015), which makes sense as educators are unlikely to spend time developing something unless they believe it will help their student to learn. However, a critique of this research is that despite being statistically significant, the benefits of some interventions are practically insignificant. For example, in a meta-analysis of meta-analysis papers on student learning, Hattie (2015, p. 83) lists "Student control over learning" as having a statistically positive effect on learning, but with an 0.01 effect size, which is so small that practically it has a negligible impact on student learning. Therefore rather than focusing on the question "What works?", Hattie (2015, p. 79) suggests that instead we should be asking "What works best?". By providing evidence on the magnitude of the learning improvement, as educators we can focus our efforts on providing guidance to students on the most effective way to use the online quizzes. This leads to the second research question, how does the way in which the student uses the formative online quizzes affect the magnitude of impact on performance in different topics in introductory accounting?

This study is motivated by the need to provide timely feedback on learning to a large number of diverse students in introductory accounting based on empirical evidence. Introductory accounting presents challenges to educators to deliver feedback for effective learning at scale because it attracts a large number of diverse students. Providing online quizzes can be one way to provide this feedback at scale. However, to optimise student learning it is important to understand how the quizzes impact performance to be able to guide students on how to effectively use the quizzes, such as if it is more effective to use the quizzes as a worked example or to self-test their knowledge. This is particularly important as much of the cohort is transitioning to independent learning in higher education for the first time, so need evidence based guidance to develop their academic skills to succeed at university (Kift, 2015). This need is enhanced in the current environment where the challenges of the COVID-19 pandemic have accelerated the digital transformation of learning and teaching, highlighting the necessity to provide effective online learning support that students can access anytime, anywhere (Rospigliosi, 2020; Sangster et al., 2020).

To evaluate the effectiveness of how students use online quizzes to learn successfully, the study modifies Biggs' presage-process-product (3P) model of learning (Biggs, 1993, 1999) as a theoretical framework to evaluate the association between online quizzes and exam performance. In a first year undergraduate accounting course at an Australian university, consistent with self-regulation theory, regression analysis found using the quizzes was associated with exam performance, particularly for topics students found difficult in their exams. Results indicated that for all topics, quiz performance is a more useful predictor of performance on the related exam question than quiz use, demonstrating that the testing effect applies to introductory accounting Finally, the study established that using the quiz as a self-test rather than a worked example was

the better strategy for learning to record journal entries, whereas using the quiz as a worked example was associated with exam performance for calculating adjusting entries, closing entries and the managerial accounting topics. These results were robust to tests controlling for self-selection bias. While using the quizzes as a worked example appears to be more efficient for certain topics, especially toward the end of the session, a very important caveat is that when students used the quizzes as a worked example, they still needed to make a genuine attempt to complete the quiz to receive the benefit.

This study contributes to the literature theoretically, methodologically and practically. Theoretically the study modifies Biggs' 3P model (1993, 1999) to show how the model can be used to evaluate the impact on performance of an individual learning intervention, such as online quizzes. It does this by modifying the process stage of the 3P model to explicitly show how online quizzes can be used by the student, either as a self-test or as a worked example. The study also demonstrates how Biggs' 3P model (1993, 1999) can be empirically operationalised by explicitly mapping determinants of student performance to the theoretical constructs suggested by Biggs (1993, 1999), thus theoretically justifying all 'control' variables included in the model rather than including them merely because they have been found in prior literature.

The study makes methodological contributions to the literature by aligning the level of analysis when assessing the association between between quiz use and exam performance. Previous studies that investigate student performance in accounting have used broad measures of performance such as class tests, final exams or overall course grade to evaluate the effectiveness of interventions on student performance (H. C. Koh, 2014, p. 460). Using such broad measures introduces noise into the analysis as the performance measures may combine several topics whereas the learning resources under investigation may focus on one specific topic. This is not

consistent with the theory of constructive alignment where learning objectives should be aligned with learning activities (the intervention) and assessment of learning outcomes (Biggs, 1996). Thus it is not clear whether results from studies that do not align the level of analysis are from the intervention or merely a reflection of the intervention comprising a larger proportion of the examination. This study overcomes this limitation and complies with the theory of constructive alignment by evaluating the association between the online quiz and exam performance on the same topic, thus responding to the call in Massoudi et al. (2017, p. 15) to investigate "impact of online learning resources on particular types of exam questions rather than the aggregate examination score". The study also makes a methodological contribution to the accounting education literature by including several tests to control for self-selection bias.

The results of the study contribute to practice by providing empirical evidence on what works best in regard to how students use the quizzes, which can be used to advise and motivate students on the most effective way to use quizzes to enhance their learning. Finally, the study contributes to the literature by providing evidence that creating non-MCQ online quizzes constructively aligned to course content is effective for student learning, evidence that may be useful in applying for grants to set up online quizzes specifically tailored to the content of their course.

The remainder of this paper is structured as follows. First, we introduce the modifications to Biggs' (1993, 1999) 3P theoretical framework. Next, we review the current accounting education literature on online quizzes and student learning to develop the hypothesis tested in the study. The methods and data are then described, followed by an empirical analysis of the results. Finally, the conclusions, limitations and further opportunities for research are discussed.

Literature Review

Theoretical framework

The current study modifies Biggs' presage-process-product (3P) model of learning (Biggs, 1993, 1999) to empirically evaluate the association between voluntary online quizzes and student learning in the context of introductory accounting (see Figure 1). In this model, *Presage* refers to antecedents to learning, such as student factors and the teaching context that can influence the way students engage in the learning activities and assessment. The *Process* stage represents the way students engage with the learning activity, while the *Product* stage refers to the learning outcomes that students are required to demonstrate competency in their assessments. Using this model responds to the call in the accounting education literature that "future research should be based on a theoretical framework" (H. C. Koh, 2014, p. 466) with the use of the 3P model particularly encouraged in the accounting education literature (Duff & Mladenovic, 2015) as it provides a comprehensive model that provides insights into the interrelations between key student factors, the teaching context, their impact on learning processes and outcomes.

[INSERT FIGURE 1 ABOUT HERE]

The current study amends the original 3P model by mapping control variables associated with student learning in accounting (H. C. Koh, 2014) to the theoretical constructs in Biggs' 3P model (1993, 1999) to operationalise the *Presage* factors. Control variables were mapped to most of the constructs in the *Presage* stage of the model, with the exception of three teaching context factors; objectives, climate/ethos and institutional procedures, which remain stable for the students in the study and thus do not exhibit enough variation to be included in the empirical

modelling. The inclusion or exclusion of the control variables in the model is guided by theory but constrained by the limitations of data availability.

The *Process* stage of the 3P model has also been expanded to detail how students engage with the online quizzes. They may either not use the quiz, they may click through the quiz just to access the solutions to use as a worked example or they may make a successful attempt and pass the quiz. The grey arrows within the *Process* stage recognise that students may attempt the quizzes as many times as they like, with each type of use demonstrating a deeper level of engagement and learning from the quizzes than the last stage.

The student approach to learning (SAL) literature (for a discussion in accounting education see Lucas and Mladenovic (2014)) models the *Process* stage of the 3P model to classify students' overall approach to learning as either deep (learning to create meaning) or surface (rote learning to pass). However, constructivist theories of learning, where learning is conceived as a process of the student constructing the meaning from the learning activity (Biggs, 1996), assumes that a deep or surface approach to learning may change in repose to a specific context (Lucas & Mladenovic, 2014). Therefore, the *Process* stage of the 3P model is modified in this study to consider the students' approach to the particular learning activity, the online quizzes, by using Marton & Säljö's (1976) original conceptions of approaches to learning as a deep-level or surface level processing of a task.

The *Product* stage of the model shows how the P*resage* and *Process* factors influence the attainment of the learning outcome, which is demonstrated by examination performance in this study. Overall, the model shows how each part of the model is linked together as an interactive ecosystem to influence student learning.

Self-regulated learning theory

Self-regulated learning theory can explain why formative online quizzes can enhance student performance in accounting. Self-regulated learning theory posits that the more effectively a student can regulate their own cognitive, behavioural, motivational and emotional/affective states, the more successful they can be at learning (Butler & Winne, 1995; Nicol & Macfarlane-Dick, 2006; Panadero, 2017). While there are many models that seek to explain and emphasise different aspects of self-regulated learning (For a review see Panadero (2017)) there are four assumptions that are common to each (Pintrich, 2004). First, students are active participants in learning, constructing their own goals, strategies, and meaning from cues in the external environment or internal reflection; second, students are able to control aspects of their learning through monitoring and regulating their cognition, motivation, behaviour, and parts of their environment; third, clear goals, criterion or standards exist against which students can evaluate their performance and make necessary changes; and fourth, that self-regulatory activities mediate the relation between student and contextual characteristics, and actual performance (Pintrich, 2004).

In line with these assumptions of self-regulated learning theory, formative online quizzes can provide students with feedback of the standards expected of them for performance, allow them to monitor and evaluate the current state of their learning compared to the required standard and to self-regulate their learning by taking action to bridge their knowledge gap to increase their understanding, which are also key components of effective feedback from formative assessment (Black & Wiliam, 1998; Ramaprasad, 1983; Sadler, 1989). Thus feedback is a key mechanism for self-regulated learning (Butler & Winne, 1995), which is facilitated through the student being

able to use the detailed feedback provided by the online quizzes at the time and place suited to them to enhance their understanding.

Of the few studies that have empirically investigated the topic of the impact of voluntary online quizzes on student performance in accounting, there have been mixed results. While controlling for other factors related to student performance in both accounting and management, Beatson et al., (2020) concluded that engagement with the MCQs in a game based mobile application, rather than demonstrated performance, had the highest power to predict final course grades. Conversely Ross et al., (2018) could not conclude that the introduction of voluntary adaptive quizzes that used MCQs was associated with increased assessment scores across consecutive teaching periods. This could be because of the use of the less effective verification feedback (correct/incorrect) that has been shown in meta-analysis to be negatively associated with student performance (Bangert-Drowns et al., 1991) or at best a very small positive effect size in computer based learning (Van der Kleij et al., 2015). Additionally, the study did not control for other factors known to be associated with performance in accounting such as academic aptitude (Al-Twaijry, 2010; Byrne & Flood, 2008; Duff, 2004; Guney, 2009; Kirk & Spector, 2006; H. C. Koh, 2014; M. Y. Koh & Koh, 1999; Lane & Porch, 2002; Uyar & Güngörmüş, 2011) making it difficult to infer the effect of the adaptive quiz on performance.

When controlling for factors associated with exam performance, Einig (2013) found the usage of formative online (MCQs) was positively associated with exam results provided students completed a minimum of five out of the seven sets of MCQs available. While the MCQ's were designed to provide verification feedback as well as elaborate feedback on why the answers were correct and were specifically designed to align with the examination questions, the results could

be interpreted that completing four or less MCQ sets is not enough to adequately cover the number of learning objectives tested in the examination.

Massoudi et al. (2017) extended the study by Einig (2013) by controlling for a wider variety of factors associated with performance and including both formative (voluntary) and summative (assessable) MCQs in their model. Massoudi et al. (2017) found that engagement with the formative quizzes, defined as achieving an above average score in that quiz compared to the cohort, was associated with exam performance only for certain quiz topics.

Together these studies that empirically investigate the association between formative online quizzes and performance reveal mixed results – that formative online quizzes are associated with examination performance (Beatson et al., 2020) only if used extensively (Einig, 2013) or only for certain topics (Massoudi et al., 2017) or perhaps not at all (Ross et al., 2018). While Beatson et al. (2020) and Ross et al. (2018) compared overall quiz use with overall performance, Einig (2013) and Massoudi et al. (2017) used overall examination performance as the dependent variable, whereas each quiz in their studies covered a different accounting topic. This introduces a levels issue into the analysis - by taking an aggregate exam measure that covers multiple topics and comparing this to several formative online quizzes each covering a separate topic, the research compares independent measures of a single intended learning outcome to an outcome variable that is a composite of several intended learning outcomes. Thus it is not clear whether the association found in these studies is driven by the formative online quiz, or is merely a reflection of that topic comprising a larger proportion of the examination. The current study is the first to overcome this limitation in the literature to align the level of analysis specifically at the topic level to investigate the how formative online quizzes are associated with exam performance for different topics.

The current study refines the measure of engagement with formative online quizzes from that used by Massoudi et al. (2017) by measuring usage to include all students who completed the formative online quiz rather than just the students who achieved an above average score on the quiz compared to the cohort. This is because students may click through the quiz and receive a score of 0, but still use the feedback to learn, so excluding these students potentially excludes students that have used the formative online quizzes as a worked example to enhance their learning. Consistent with self-regulated learning theory that the online quizzes provide the opportunity for students to actively participate in learning, monitor their progress against standards, and allow student to take action to increase understanding, it is hypothesised:

H1: There is a positive association between usage of the formative online quiz and exam performance.

Testing effect

While prior studies investigate the use of formative online quizzes and performance, another limitation of the literature is that little is known about the impact on student performance depending on how students use the quizzes. One way students may use the quizzes is to self-test the current state of their knowledge on the topic, and to learn from any mistakes they made in the process from the feedback. This is an example of the testing effect, where successfully taking a test has been shown in the cognitive psychology literature to be more efficient for long-term retention than studying the material to be learned (Roediger & Butler, 2011; Roediger & Karpicke, 2006; Wheeler et al., 2003) and is even more beneficial when feedback is given (Kang et al., 2007; McDaniel et al., 2007; Roediger & Butler, 2011; Vojdanoska et al., 2010) especially when the format of the test requires production or recall of material rather than mere recognition in a multiple choice question (Greving & Richter, 2018; Kang et al., 2007; McDaniel et al.,

2007). The testing effect also works as it allows students to practice the skill of recall that they are required to demonstrate in examinations (Roediger & Karpicke, 2006).

Studies supporting the efficacy of the testing effect in the accounting education literature mainly focus on compulsory, rather than formative quizzes, but do report positive associations between the quizzes and examination performance. Shoulders and Hicks (2008) reveal that requiring intermediate accounting students to succeed in paper based diagnostic exams before taking summative exams that count toward the final grade increases performance on the summative exams, although the individual feedback given to the students by the instructor makes this approach impractical in larger classes. Compulsory pre- and post-lecture online quizzes have also been found to be associated with examination performance in intermediate accounting (Brink, 2013). Wooten (2016) found compulsory online tests were associated with higher examination performance than in class tests in auditing students, however this result is confounded by other factors including the extra class time students had to engage in learning in the online test condition. While Beatson et al. (2020) reported overall performance in their online quizzes to be associated with higher examination performance in introductory accounting, their study compared overall quiz performance with overall examination performance, so whether this result holds for all accounting topics or just some is yet to be investigated. In line with the testing effect in cognitive psychology where successfully completing a test is more effective for long-term learning than studying, it is predicted that:

H2: There is a positive association between performance on the formative online quiz and exam performance.

Self-testing versus using the quizzes to access worked examples

Although students can use the quiz to successfully self-test their knowledge, alternately they may

use the quiz to either click through and access the feedback as a worked example of how to complete that type of question. Such worked examples can help students learn more efficiently by offering guidance and ways to approach the solution, and have been found to be a more efficient learning strategy than problem solving for students with no prior knowledge of accounting (Halabi et al., 2005). The feedback in the online quizzes under investigation combine both the answer and a worked example of the process to be followed, a combination that has been found to increase performance with less practice (Wynder & Luckett, 1999).

While using the online quizzes as a worked example or to self-test knowledge can provide the student with feedback, it is not clear which approach is more effective for learning. Beatson et al. (2020) showed that for students who entered university from secondary school, quiz use has greater predictive power, whereas when the whole accounting cohort is considered, performance on the quizzes has greater predictive power. Thus it is unclear whether using the quiz or demonstrating performance on the quiz is more effective for learning in accounting students, and whether this differs depending on the different topics covered by each quiz is yet to be investigated in the literature.

The desirable difficulty framework (Bjork, 1994, 1999) provides theoretical guidance that demonstrating performance is likely to be more effective than using the quiz to access a worked example. The desirable difficulty framework proposes that difficult but successful processing is better for long term memory than difficult but unsuccessful processing (Pyc & Rawson, 2009), suggesting that demonstrating higher performance on the online quizzes is likely to be associated with higher exam performance.

Demonstrating performance on the quiz is also an action that may indicate the application of a deeper approach to learning the content, whereas using the quiz to access the answer may be

conceptually linked to a surface approach to learning. Deep approaches to learning are characterised by an intention to understand the topic, creating meaning and relating it to other experiences, whereas surface approaches to learning entails viewing concepts in isolation, relying on rote-learning and memorisation (Duff & McKinstry, 2007; Duff & Mladenovic, 2015). The current study does not explicitly measure approaches to learning using self-report inventories, since the primary function of these measures is not to predict performance (Duff & Mladenovic, 2015). However, one might infer that students using the online quizzes to self-test their knowledge can be likened to a deeper search for understanding, whereas using the quiz to get the solutions may be more akin to a shallow approach to using the quizzes to help know how to answer the question. Since deep approaches to learning have been found to be positively associated with performance in accounting (Byrne et al., 2002; Davidson, 2002; Duff, 2004), and surface approaches negatively associated with performance (Booth et al., 1999; Byrne et al., 2002; Duff, 2004; Duff & Mladenovic, 2015; Ramburuth & Mladenovic, 2004) it is hypothesised that:

H3: Students who use the quizzes to successfully self-test their knowledge will perform better in examinations than students who use the quizzes to access the worked example answer.

Research method

Participants

A convenience sample of all students enrolled in the course in 2019 session 1 (1,451 students) and session 2 (548 students) were invited to participate in the study. Students who were missing data or chose to opt-out of the research were removed from the sample, leaving 1,900 student observations in the full sample. Table 1 presents the sample construction for session 1, session 2

and the full sample.

[INSERT TABLE 1 ABOUT HERE]

Context

The study was conducted over two sessions in the first accounting course at a large metropolitan Australian university. The first accounting course was chosen as it is a compulsory course undertaken by all students completing a business degree at the university so provided a sufficiently large sample size for the statistical analysis. The course was structured as a 1.5 hour interactive lecture supported by a 1.5 hour tutorial delivered by the same team of permanent staff and sessional academics across both sessions. Students could choose between 2 assessment options: a 40% mid-session examination and 60% final examination, or a 10% homework and class participation mark, 30% mid-session examination and 60% final examination. Where the homework option was selected, tutorial attendance each week was compulsory, but was not compulsory otherwise. The content and assessment tasks remained consistent between both sessions and covered both financial and managerial accounting topics.

Quiz Design

The online quizzes were designed, coded and edited by the first author with additional coding assistance provided by a research assistant. In a similar process to Einig (2013) the examination content was reviewed and a series of online quizzes were developed to match the learning objectives of the exam questions to ensure alignment (Biggs, 1996) between the online quizzes and the assessments in the course. Where possible, numerical values were algorithmic, with numbers changing for each student. In this way students had to understand the process and could

not memorise the answer. Verification (correct/incorrect) feedback was provided to all students immediately after submitting the quiz. Students who answered the question incorrectly were provided with extensive elaborated feedback that described both the process of deriving the correct outcome or the reason why the answer was correct to enable to the student to learn from the feedback provided. (See Figure 2 for an example exam question, Figure 3 for the related online quiz and Figure 4 for the quiz feedback).

[INSERT FIGURES 2, 3 and 4 ABOUT HERE]

In total 15 online quizzes were developed with at least one quiz covering each of the 11 topics in the course. The current study focuses on 9 of these quizzes that correlate with a substantial section of the exams. The development of the quizzes was funded by a grant from the university.

The online quizzes opened for students to use one week before the lecture on that topic and remained available for students to attempt as many times as they liked before their exams. Since the quizzes were designed to be a formative quiz for students to self-assess their knowledge gap and learn from the feedback provided, the results of the quizzes were not counted toward the summative mark for the course and students were not given extra credit for attempting the quizzes. Instead, students were strongly encouraged to use the quizzes by announcements in lectures, weekly tutorials, in the weekly student tutorial guide, subject outline, and through the learning management system announcements and content pages. Additionally, tailored emails were sent to students most weeks, either encouraging students that did not attempt the quiz to use it, encouraging additional study and to retake the quiz for students with low to average quiz performance (less than 75%) or congratulating them on their high achievement (>75%) on the quiz. This strategy followed Einig's (2013) recommendation that

advertising is more effective in encouraging students to use the online quizzes than restricting access to certain dates.

Procedure

Main Statistical Model

To examine hypothesis 1, the association between usage of the formative online quizzes and exam performance on the related exam question, the following ordinary least squares (OLS) multiple regression model was used:

$$\text{RelatedExamQn} = \beta_0 + \beta_1\text{OnlineQuizUse} + \beta_2\text{AtTute} + \beta_3\text{HWStudent} + \beta_4\text{FirstSemUni} + \beta_5\text{WAMExAccA} + \beta_6\text{EAL j} + \beta_7\text{AccMaj} + \beta_8\text{Repeat} + \varepsilon \quad (1)$$

A similar model was used to test hypothesis 2, the association between performance on the formative online quizzes and exam performance on the related exam question:

$$\text{RelatedExamQn} = \beta_0 + \beta_1\text{OnlineQuizPerf} + \beta_2\text{AtTute} + \beta_3\text{HWStudent} + \beta_4\text{FirstSemUni} + \beta_5\text{WAMExAccA} + \beta_6\text{EAL j} + \beta_7\text{AccMaj} + \beta_8\text{Repeat} + \varepsilon \quad (2)$$

To test hypothesis 3, a piecewise regression was used to simultaneously test if there are different linear trends depending on how the student used the quiz. Students who used the quiz predominantly as a worked example were defined as achieving 0-49% on the quiz, while students who achieved a score of 50-100% on the quiz were considered to be using the quiz to successfully self-test their understanding of the topic. The following piecewise model is based on model (2) with the addition of the dichotomous variable to indicate whether the student achieved a pass on the quiz, QzPass, which is assigned a value of 1 if the student obtained a score of 50-

100% on the related quiz, and 0 otherwise. The model also interacts QzPass and the student's performance score on that quiz topic:

$$\text{RelatedExamQn} = \beta_0 + \beta_1\text{OnlineQuizPerf} + \beta_2\text{QzPass} + \beta_3\text{OnlineQuizPerf*QzPass} + \beta_4\text{AtTute} + \beta_5\text{HWStudent} + \beta_6\text{FirstSemUni} + \beta_7\text{WAMExAccA} + \beta_8\text{EAL j} + \beta_9\text{AccMaj} + \beta_{10}\text{Repeat} + \varepsilon \quad (3)$$

All analysis were performed in R (R Core Team, 2019) using the apaTables package (Stanley, 2018) for the correlation tables and the stargazer package (Hlavac, 2018) for regression tables.

Variable Definitions

Table 2 summarises the variables used in the study and how they are measured. The dependent variables of interest that represent the *Product* stage of the modified 3P model are the exam score for each topic expressed as a percentage. The independent variables of interest that comprise the *Process* stage of the model include quiz use, a dichotomous variable coded 1 where the student completed the online formative quiz for that topic, and coded as 0 otherwise, and quiz performance, which is the highest score the students attained on the online quiz for that topic expressed as a percentage. The highest score was chosen as this represents whether the student has used the quiz to successfully self-test their knowledge if they passed the quiz, or if they used the quiz as a worked example if they scored <50% on the quiz. Due to the technical limitations

of the online system[1], the adjusting entries topic was split into two quizzes; one on journalising the adjusting entry and another quiz on calculating the values of the adjustments, whereas these were combined in the exam.

[INSERT TABLE 2 ABOUT HERE]

Panel B of Table 2 presents how the control variables included in the study are measured, which correlate to the *Presage* stage of the 3P model. All factors were chosen for their potential to influence students use of the online quizzes and/or their exam performance. Factors of the teaching context that may differ between students are class attendance (AtTuteTopic), controlled for because it may reflect a motivation to succeed (H. C. Koh, 2014) and is correlated with students' use of online resources (Lento, 2018), and the choice to be a homework student (HWStudent), which may also be an indication of being motivated to achieve higher performance. Student factors include university experience (FirstSemUni) as students who are in their first semester of university have yet to acquire the academic skills and literacies required to transition to the independent learning required to succeed at university (Kift, 2015, p. 54). Academic aptitude (WAMExAccA) was included as it has been found to be the most consistent determinant of academic performance in accounting (H. C. Koh, 2014), while students that speak a language other than English at home (EAL) potentially show problems in translation on top of comprehension of content (H. C. Koh, 2014). Students who have chosen to major in accounting

[1] The learning management system was not able to simultaneously have drop-down boxes to select the account names and have numerical calculations that change for each student within the same question.

(AccMaj) may be more motivated to succeed (Guney, 2009) while repeat students (Repeat) may have found failure demotivating (Prinsloo et al., 2010).

Data

Examination performance data were collected from the course records. The online quiz use and performance data were downloaded from the university's learning management system (Blackboard). Data on student characteristics were collected from the central student records of the university. Continuous variables were assessed for the assumption of normality and all tests re-run with appropriate transformed variables. Since the results remained consistent in terms of significance, the results reported are with non-transformed data for ease of interpretation. The research was approved by the university's human research ethics committee prior to data collection.

Results and discussion

Descriptive Statistics

Table 3 reports the descriptive statistics for the variables used in the study.

[INSERT TABLE 3 ABOUT HERE]

Voluntary engagement with the online quizzes was quite high, with usage declining over the duration of the session, consistent with prior studies (Einig, 2013; Massoudi et al., 2017). Table 3 Panel B shows between 71.0% of students early in the session and 36.6% of students later in the session used the online quizzes at least once. This is higher than the 1.9% to 45.5% of students using the formative quizzes as reported by Massoudi et al. (2017, p. 7) and 33.6% reported by Beatson et al. (2020, p. 1), but comparable to the 43% to 75% overall completion

rate reported in Einig (2013, p. 434), who constructed their own quizzes aligned with the learning objectives in their exams, similar to the current study. Performance on the quizzes generally also declined over time (Table 3 Panel A), with the average score ranging from 82% on the earlier quizzes to 44% on the later quizzes, although this trend was not linear.

Table 4 reports the Pearson correlation matrix for the variables used in this study. The only variables that have a correlation coefficient greater than 0.5, which is considered large (Field et al., 2012, p. 212), are theoretically expected correlations.

[INSERT TABLE 4 ABOUT HERE]

Hypothesis 1 - Quiz Use and Exam Performance

Table 5 shows the results of the main regression model for hypothesis 1, that there is a positive association between usage of the formative online quiz and exam performance on the associated exam question covering the same intended learning outcome.

[INSERT TABLE 5 ABOUT HERE]

Adjusted R^2 values reveal the models explain between 20.5% (for the topic of Receivables) and 33.3% (for the topic of adjusting entries) of examination performance, with all models statistically significant at the 1% level. Variance inflation factors (VIF) for all coefficients were below 5 indicating multicollinearity is unlikely to be an issue in the models (James et al., 2013, pp. 101-102). All of the coefficients for the online quizzes are positive and highly significant ($p<0.01$) supporting hypothesis 1.

To explain why some quiz topics have a higher coefficient than others, the quiz coefficients were compared to see if there was a trend between the coefficients and the order the students learnt the topics during semester, the order of the exam questions (students may perform

worse in the later sections of an exam if they run out of time) or the order of difficulty of the topic as measured by their average performance on that section in the exam. Interestingly, the only one that exhibited a clear trend was that the harder the exam topic, the higher the coefficient of the association between quiz use and exam performance, with the exception of the topic of adjusting entries. Table 6 shows the exam topics listed from most difficult to least difficult based on average exam performance. The coefficient of association between quiz use and exam performance is largest for the most difficult topic, activity based costing, and smallest for the topic where students performed the best in their exams. This may indicate that using the quiz was more impactful for the topics the students found more difficult.

[INSERT TABLE 6 ABOUT HERE]

Hypothesis 2 - Quiz Performance and Exam Performance

Table 7 shows the regression results of the association between the maximum score obtained on the online quiz and the score obtained on the related exam question while controlling for factors associated with performance.

[INSERT TABLE 7 ABOUT HERE]

All models were statistically significant at the 1% level, and the VIF for all coefficients were below 5, again indicating multicollinearity is not an issue (James et al., 2013, pp. 101-102). The adjusted R^2 from the models range from 15.0% for the receivables topic in the final exam to 30.0% for the recording journal entries topic for the mid-session exam. Achieving a higher score in the online quiz is highly statistically significant ($p<0.01$) and positively related to exam performance for all topics, providing support to hypothesis 2.

Hypothesis 3 - Quiz Use as a Self-Test or Worked Example

The piecewise regression results for hypothesis 3 are reported in table 8. While all models are significant at the 1% level, whether exam performance was better when students were using the quiz as a self-test or worked example differed between topics. For the learning to record journal entries topic, students who use the quiz as a self-test performed significantly better (-2.08 + 0.980 = 0.772) in their exam questions on that topic than students who did not pass the quiz.

[INSERT TABLE 8 ABOUT HERE]

There was no significant difference between using the quiz as a self-test or worked example for the adjusting journal entry quiz, when also controlling for the student's performance in the calculating adjusting entries quiz. However, students benefit more from using the calculating adjusting entries quiz when used as a worked example (0.242) compared with using this quiz as a self test (0.242 – 0.149 = 0.093). This may be because the calculations build upon their prerequisite mathematical ability, so accessing the solutions as a worked example may be enough for their learning.

The closing entries topic showed similar findings, that using the quiz as a worked example had a significantly higher magnitude of association with exam performance (0.475) than using the quiz to self-test knowledge (0.475 – 0.366 = 0.109). Similarly the management accounting topics of activity based costing, cost-volume-product analysis, and decision making all indicated that using the quizzes as a worked example was significantly associated with exam performance on that topic.

Together these results showed partial support for hypothesis 3, that voluntarily using the quizzes to self-test knowledge was associated with significantly higher exam performance than using the quiz as a worked example only for the topic of recording journal entries. This may be

because journal entries are new to the students, so require more practice and feedback to learn. Calculating adjusting entries and closing entries quizzes were significantly associated with exam performance for both types of use, however using these quizzes as a worked example had the higher coefficient. The management accounting topics were significantly associated with exam performance only when used as a worked example. Since these topics were at the end of session it may indicate that students did not have time to repeat the quiz to demonstrate performance, but they were still using the quiz as a worked example to successfully learn.

While using the quizzes as a worked example appears to be more efficient for certain topics, especially toward the end of the session, an interesting caveat is that the students still need to engage with the quiz to receive the benefit. For the quizzes where using the quiz as a worked example appeared to be the better strategy, the large magnitude of the coefficient suggested that of these students who failed the quiz, the better they did on the quiz, the better exam performance. This suggests that the benefit gained from the quizzes increases the more the students engage with the quiz, so that attempting the quiz even if they fail it is better than clicking through it merely to get the answers.

Additional analysis to test for self-selection bias

A major concern when empirically assessing the effectiveness of voluntary educational interventions on student performance is the issue of self-selection bias – that students who actively use the quizzes are the ones that are motivated to do well anyway, so that any association between the intervention (online quizzes) and exam performance is due to better students selecting to use the quizzes rather than the quizzes assisting performance. Since a randomised controlled experimental design is impossible in the current study, instead, two methods were investigated to provide supporting evidence that the main results were not driven

by self-selection bias; using students who completed some but not all quizzes as their own control, and propensity score matching.

Using students as their own control

The data allowed a quasi-experimental investigation of self-selection bias by comparing the average exam score for questions where students used the quizzes, to their exam score where an online quiz was available but that same student did not use it, thus using the student as their own control. There were 1,082 students (56.9% of the sample) who completed some but not all of the online quizzes and the related exam question. Two variables were constructed to compare the students results on the exam questions related to the online quizzes:

$$\text{Total exam percent when quiz used} = \frac{(\sum \text{Raw exam score for related questions where quiz used})}{(\sum \text{Total exam score for related questions where quiz used})}$$

$$\text{Total exam percent when quiz not used} = \frac{(\sum \text{Raw exam score for related questions where quiz not used})}{(\sum \text{Total exam score for related questions where quiz not used})}$$

The mean exam score (percent) for exam questions where the student did the corresponding online quiz (M = 0.55, SD = 0.23, n = 1,082) was 21% higher than the mean exam score when the same student did not complete the corresponding online quiz (M = 0.34, SD = 0.25, n = 1,082). A paired t-test showed a highly significant difference $t(1081) = 26.77$, $p < .001$ with a large effect size (Cohen's d = 0.81, 95% CI [0.73, 0.89]). These results provide additional support for the main finding that using the quizzes is associated with exam performance.

Propensity score matching

To further account for whether the voluntary use of each quiz was affected by self-selection bias due to observable factors, and to reduce concerns that the regression models contained biased estimates due to functional form misspecification of the models (Shipman et al., 2017),

propensity score matching was performed for each online quiz in the study. Propensity scores were estimated using the following first-stage estimation model to calculate the propensity score for each student:

$$\text{OnlineQuizUse} = \beta_0 + \beta_1\text{AtTute} + \beta_2\text{HWStudent} + \beta_3\text{FirstSemUni} + \beta_4\text{WAMExAccA} + \beta_5\text{EAL} + \beta_6\text{AccMaj} + \beta_7\text{Repeat} + \varepsilon \quad (4)$$

The covariates chosen in the first stage estimation model are the same as the control variables used in the main regression models for internal consistency (Shipman et al., 2017). Table 9 shows the results of the first stage estimation model for each of the online quiz topics.

[INSERT TABLE 9 ABOUT HERE]

Students were matched on their estimated propensity score from the first stage model using the MatchIt package (Ho et al., 2011) in R using the nearest neighbour matching method without replacement. A caliper of 0.2 was applied to minimise the average standardised mean difference between covariates in the matched sample without losing too many matched pairs, as losing too many matches can introduce bias into the matched sample (Austin, 2011).

Covariate balance in the matched sample was then assessed to see how successful it was in reducing the difference between the covariates while maximising the number of matched pairs. Table 10 reports the mean differences between the covariates in the matched samples for each quiz topic. The difference in means is not statistically significant for most variables, with two minor exceptions. Students weighted average mark excluding accounting A and English as an additional language students were statistically significantly different between groups, however the magnitude of the difference was considered immaterial. Therefore, no practically

significant differences between the matched sample are apparent, so the matching is considered appropriate.

[INSERT TABLE 10 ABOUT HERE]

Table 11 replicates the main results for hypothesis 1 using the matched sample for each online quiz. The results are consistent with those reported in table 5, with the magnitude of the coefficients and the statistical significance of the variables generally consistent between the full regression model and the model with the matched sample. As an additional robustness check to see if the results are sensitive to the selected propensity score matching method, several additional matching methods available in the MatchIt package in R (Ho et al., 2011) were run for each online quiz topic. These other methods revealed coefficients less than 0.06 different to the original sample (untablulated). This indicates that the results are robust to the choice of matching models, reducing concerns that the regression models estimated in table 5 contained biased estimates.

[INSERT TABLE 11 ABOUT HERE]

Theoretically the self-selection bias in this case is likely to be driven by unobservable factors such as student motivation, therefore methods that control for self-selection due to unobservable factors are appropriate (Tucker, 2010). Of these, an instrumental variables approach is unable to be used because finding an observable variable that is associated with the endogenous variable (quiz use) but not the outcome variable (exam performance) and that can be measured is unlikely. The results of the study need to be interpreted in light of this limitation.

Conclusion

The aim of the current study was to understand the different ways students can voluntarily

engage in online quizzes, and whether the different ways in which students may use these quizzes has a different magnitude of impact on their performance in introductory accounting. Results from hypothesis 1 showed that using the quizzes was associated with exam performance, particularly for topics students found difficult in their exams, with the results robust to propensity score matching approaches to test for self-selection bias. This suggests students are using the quizzes to self-regulate their learning.

Hypothesis 2 was also supported, with the magnitude of the coefficients for the association between performance on the quiz and related exam performance higher than the coefficient for quiz use. This indicates that quiz performance is a more useful predictor of exam performance than quiz use for all topics, and demonstrates that the testing effect applies to introductory accounting. The results were consistent with prior literature that showed that overall quiz performance is a better predictor for overall exam performance rather than overall quiz use (Beatson et al., 2020), and contributes to the literature by demonstrating that this finding applies to all topics covering both introductory financial and managerial accounting.

The results of this study may explain the inconsistencies found in the prior literature where voluntary online quiz use was found to be associated with exam performance only if used extensively (Einig, 2013) or only for certain topics (Massoudi et al., 2017). These studies mismatched the levels in their analysis by assessing the association between separate quiz topics and overall exam performance; insignificant results would be expected if the quiz topic only comprised of a small proportion of the overall exam. The current study demonstrates the importance of ensuring the way the variables are measured validly match the underlying phenomenon being represented, and that the dependent and independent variables are compared

at the same level of analysis, avoiding, for example, the comparison between an individual topic and an aggregate outcome measure of performance.

Finally, the study established that using the quiz as a successful self-test was found to be the better strategy for learning journal entries, whereas using the quiz as a worked example was the more efficient strategy for calculating adjusting entries, closing entries and the managerial accounting topics, providing students make a genuine attempt at the quiz before accessing the solutions. The results suggest that the way in which students use quizzes changes over time, with the effectiveness of each strategy changing for each topic. Context, then, may play a greater role in the strategies students select to study at a given point in time, a point also acknowledged by Biggs (1999, p. 19). At the beginning of session where students have more time they can enact a deep-processing way of learning through self-testing their knowledge. As the session progresses and time pressure and competing priorities increase, the students are comparatively more successful when they switch to more of a surface-level processing way of learning by using the quizzes as a worked example. This is consistent with the literature that students are likely to adopt surface approach to leaning when burdened by a heavy workload (Biggs, 1999, p. 19; Entwistle & Tait, 1990). Using the quiz solutions as a worked example to aid understanding may prove to be a more effective study strategy if, rather than repeat the quiz until they can demonstrate understanding, the student instead spends that time learning other topics they are less sure of.

While using the quizzes as a worked example appears to be more efficient for certain topics, especially toward the end of the session, a very important caveat is when students used the quizzes as a worked example, they still needed to make a genuine attempt to complete the

quiz to receive the benefit. Overall, the results of this study add to the growing body of evidence that the voluntary use of online quizzes can help students learn introductory accounting.

Implications for educators

The study has two main implications for accounting educators. First, creating online quizzes that are constructively aligned to match the course objectives and assessment items are worth the time and effort as they are effective for student learning in introductory accounting and are used more than quizzes designed by external providers. The second implication is that the study provides evidence that educators can present to students to show that, in order to get the most benefit from the quizzes, the student must actively make a genuine attempt to complete the quiz and not merely access it to only obtain the solutions.

Implications for researchers

The research design of the current study makes three methodological improvements to the way the accounting education literature has addressed the question of the association between voluntary quiz use and exam performance. First, it shows how Bigg's 3P model (1993, 1999) can be used as a clear theoretical framework to guide the design of the analysis. It shows how the model can be operationalised to theoretically justify the inclusion of the control variables and used to assess the association between an educational intervention and student performance. Second, it shows the importance of matching the level of analysis between the learning activity being assessed and the outcome variable. Inconsistent results can be obtained when an educational activity on one topic is compared to a performance outcome that contains several topics. The study makes the recommendation that future research takes care to match the topic of the learning activity to the topic of the performance measure when investigating the effectiveness

of educational interventions. Finally, while self-selection bias has been recognised in the literature as an issue when assessing the effectiveness of voluntary learning activities, prior studies have controlled for this merely by using control variables in the analysis (Einig, 2013). The current study demonstrates how propensity score matching can be used to control for self-selection bias, providing greater confidence for the results in the absence of a fully randomised trial.

Limitations and Future Research

The main limitation common to all empirical investigations of voluntary educational interventions, is that while the results show a correlation between voluntarily using the online quizzes and performance, this does not prove causation. While efforts have been made to control for various factors that may affect performance, and robustness tests were performed to increase confidence in the results, in the absence of a fully randomised study, causation can not be attributed to the online quizzes and the association with performance.

An interesting observation from the study was the observed trend that using the quiz was more impactful for topics students found more difficult. Future research could replicate the study to see if this finding is an anomaly unique to the current sample, or if this finding holds in different universities in different countries.

The current research was undertaken when students studied on-campus and their examinations were in person and on paper. Future research can investigate whether the way in which students use the quizzes and their impact on learning was more or less effective when higher education has moved to online learning and online exams courtesy of the global pandemic of 2020. The study was conducted at one university in one year, limiting the ability of the findings to be generalised across other contexts.

Introductory accounting is a course that attracts a large, diverse student cohort. Clearly, with such diversity, an intervention is expected to have different effects on students with different characteristics. If the future of e-learning is projected to be personalised (Dron & Anderson, 2016), to be able to provide personalised guidance on what may be most effective for students' learning, we need empirical evidence of what is likely to work for different types of students. Future research can explore the effects of different student characteristics has on their voluntary engagement with the quizzes and the association with performance.

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Table 1. Sample Selection

Criteria	Session 1		Session 2		Total	
Students enrolled in Accounting A	1451		548		1999	
Less: Opt out students	39	(2.7%)	14	(2.6%)	53	(2.7%)
Subtotal	1412		534		1946	
Less: Students with missing information	31		15		46	
Full sample	1381		519		1900	

Table 2. Variable Definitions.

Panel A: Dependent and Independent Variable Names

Accounting topic	Dependent variable names	Independent variable names	
	Related exam questions	Quiz use variables	Quiz performance variables
Financial accounting			
Journal entries	MSExJournal	OnQuizJournalUse	OnQuizJournalPerf
Adjusting entries	MSExAdjust	OnQuizAdjJnlUse	OnQuizAdjJnlPerf
		OnQuizAdjCalcUse	OnQuizAdjCalcPerf
Closing entries	EndExClose	OnQuizCloseUse	OnQuizClosePerf
Inventory	EndExInv	OnQuizInvUse	OnQuizInvPerf
Receivables	EndExReceive	OnQuizNotesRecUse	OnQuizNotesRecPerf
Management accounting			
Activity Based Costing (ABC)	EndExABC	OnQuizABCUse	OnQuizABCPerf
Cost-Volume-Profit Analysis (CVP)	EndExCVP	OnQuizCVPUse	OnQuizCVPPerf
Decision Making (DM)	EndExDM	OnQuizDMUse	OnQuizDMPerf
Measurement definition	Students' raw examination score converted to a percentage.	Students who completed the quiz at least once = 1, otherwise 0	Students' highest score on quiz converted to a percentage.

Table 2. Variable Definitions

Panel B: Control Variable Names

Variable	Definition
Continuous Variables	
WAMExAccA	Weighted average mark of all courses attempted excluding introductory accounting expressed as number out of 100.
Dichotomous variables	
AtTuteJournal	Students who attended the tutorial on journal entries = 1, otherwise 0
AtTuteAdjClose	Students who attended the tutorial on adjusting and closing entries = 1, otherwise 0
AtTuteInvCostFlow	Students who attended the tutorial on inventory = 1, otherwise 0
AtTuteReceivable	Students who attended the tutorial on receivables = 1, otherwise 0
AtTuteABC	Students who attended the tutorial on ABC = 1, otherwise 0
AtTuteCVP	Students who attended the tutorial on CVP = 1, otherwise 0
AtTuteDM	Students who attended the tutorial on decision making = 1, otherwise 0
HWStudent	Students who voluntarily selected to have 10% of their overall mark allocated to tutorial participation and homework = 1, otherwise 0
FirstSemUni	Students who are in their first semester of university = 1, otherwise 0
EAL	Students who speak a language other than English at home = 1, otherwise = 0
AccMaj	Students enrolled in the accounting major = 1, otherwise = 0
Repeat	Students who are repeating the course = 1, otherwise = 0

Table 3. Descriptive Statistics

Panel A: Continuous Variables

Variables	*n*	*M*	*SD*	*Min*	*Max*
Dependent variables					
MSExJournal	1832	0.66	0.30	0	1
MSExAdjust	1832	0.57	0.30	0	1
EndExClose	1866	0.35	0.40	0	1
EndExInv	1866	0.52	0.28	0	1
EndExReceive	1866	0.37	0.36	0	1
EndExABC	1868	0.33	0.34	0	1
EndExCVP	1868	0.47	0.36	0	1
EndExDM	1868	0.40	0.32	0	1
Independent variables					
OnQuizJournalPerf	1347	0.82	0.21	0	1
OnQuizAdjJnlPerf	1349	0.72	0.29	0	1
OnQuizAdjCalcPerf	1091	0.45	0.30	0	1
OnQuizClosePerf	937	0.49	0.36	0	1
OnQuizInvPerf	859	0.55	0.36	0	1
OnQuizNotesRecPerf	1068	0.65	0.32	0	1
OnQuizABCPerf	774	0.44	0.40	0	1
OnQuizCVPPerf	780	0.58	0.35	0	1
OnQuizDMPerf	695	0.55	0.37	0	1
Control variables					
WAMExAccA	1900	65.66	11.65	4.33	91.67

Table 3. Descriptive Statistics

Panel B: Dichotomous variables

Variables	*n*	*% (n=1900)*
Independent variables		
OnQuizJournalUse	1347	70.9
OnQuizAdjJnlUse	1349	71.0
OnQuizAdjCalcUse	1091	57.4
OnQuizCloseUse	937	49.3
OnQuizInvUse	859	45.2
OnQuizNotesRecUse	1068	56.2
OnQuizABCUse	774	40.7
OnQuizCVPUse	780	41.1
OnQuizDMUse	695	36.6
Control variables		
AtTuteJournal	1562	82.2
AtTuteAdjClose	1448	77.7[a]
AtTuteInvCostFlow	1490	78.4
AtTuteReceivable	1363	77.5[a]
AtTuteABC	1304	70.0[a]
AtTuteCVP	1251	68.4[a]
AtTuteDM	1161	61.1
HWStudent	1359	71.5
FirstSemUni	1096	57.7
EAL	788	41.5
AccMaj	209	11.0
Repeat	186	9.8

[a] Attendance data missing for several classes. Percentage calculated as a proportion of data available.

Table 4. Pearson Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. MSExJournal																
2. MSExAdjust	.67***															
3. EndExClose	.36***	.44***														
4. EndExInv	.42***	.44***	.42***													
5. EndExReceive	.39***	.43***	.44***	.44***												
6. EndExABC	.37***	.41***	.36***	.40***	.36***											
7. EndExCVP	.38***	.39***	.32***	.37***	.37***	.49***										
8. EndExDM	.36***	.37***	.32***	.34***	.36***	.45***	.59***									
9. OnQuizJournalPerf	.48***	.40***	.31***	.28***	.30***	.27***	.25***	.23***								
10. OnQuizAdjJnlPerf	.35***	.44***	.31***	.28***	.33***	.28***	.26***	.23***	.53***							
11. OnQuizAdjCalcPerf	.31***	.41***	.36***	.30***	.29***	.32***	.24***	.29***	.42***	.49***						
12. OnQuizClosePerf	.27***	.32***	.36***	.23***	.21***	.28***	.25***	.26***	.40***	.44***	.56***					
13. OnQuizInvPerf	.33***	.37***	.33***	.37***	.27***	.35***	.27***	.26***	.38***	.39***	.49***	.51***				
14. OnQuizNotesRecPerf	.35***	.38***	.33***	.28***	.32***	.32***	.26***	.22***	.45***	.48***	.50***	.52***	.53***			
15. OnQuizABCPerf	.25***	.29***	.31***	.27***	.27***	.48***	.30***	.34***	.38***	.38***	.48***	.46***	.54***	.47***		
16. OnQuizCVPPerf	.30***	.32***	.25***	.24***	.30***	.41***	.40***	.35***	.39***	.42***	.43***	.47***	.49***	.46***	.64***	
17. OnQuizDMPerf	.25***	.29***	.30***	.26***	.26***	.35***	.34***	.35***	.38***	.41***	.46***	.45***	.47***	.42***	.56***	.60***

Note: *p<0.1; **p<0.05; ***p<0.01

Light grey items do not appear in the same regression models, so are not relevant to the analysis.

Table 4. Pearson Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
18. OnQuizJournalUse	.32***	.34***	.25***	.25***	.29***	.20***	.20***	.21***	NA	.20***	.09***	.14***	.09**	.11***	0.05	0.04
19. OnQuizAdjJnlUse	.32***	.39***	.28***	.27***	.33***	.23***	.21***	.20***	.21***	NA	.11***	.09***	.07**	.12***	.09**	.07**
20. OnQuizAdjCalcUse	.30***	.39***	.27***	.27***	.33***	.24***	.21***	.22***	.21***	.30***	NA	.17***	.14***	.19***	.12***	.15***
21. OnQuizCloseUse	.32***	.40***	.37***	.34***	.37***	.29***	.24***	.24***	.26***	.34***	.30***	NA	.17***	.24***	.18***	.17***
22. OnQuizInvUse	.26***	.31***	.29***	.37***	.36***	.31***	.24***	.25***	.19***	.24***	.24***	.21***	NA	.21***	.17***	.16***
23. OnQuizNotesRecUse	.27***	.35***	.28***	.30***	.35***	.26***	.21***	.22***	.19***	.22***	.25***	.16***	.11***	NA	.15***	.17***
24. OnQuizABCUse	.26***	.31***	.29***	.31***	.33***	.44***	.29***	.30***	.19***	.20***	.24***	.21***	.22***	.18***	NA	.13***
25. OnQuizCVPUse	.23***	.30***	.29***	.28***	.34***	.39***	.33***	.33***	.17***	.23***	.23***	.20***	.21***	.22***	.22***	NA
26. OnQuizDMUse	.22***	.30***	.28***	.26***	.33***	.39***	.32***	.37***	.17***	.21***	.27***	.18***	.22***	.21***	.28***	.21***
27. WAMExAccA	.48***	.49***	.42***	.40***	.38***	.36***	.41***	.42***	.29***	.33***	.32***	.29***	.30***	.31***	.29***	.31***
28. AtTuteJournal	.12***	.16***	.12***	.12***	.09***	.08***	.10***	.10***	.11***	.12***	.09***	.10***	0.06	.11***	0.06	.09**
29. AtTuteAdjClose	.16***	.21***	.18***	.15***	.15***	.08***	.11***	.13***	.12***	.12***	.10***	.11***	.10***	.14***	.10***	.08**
30. AtTuteInvCostFlow	.18***	.24***	.18***	.23***	.16***	.16***	.15***	.17***	.12***	.14***	.12***	0.06	.09***	.10***	0.02	0.05
31. AtTuteReceivable	.16***	.20***	.16***	.14***	.15***	.09***	.10***	.12***	.10***	.10***	.11***	.08**	.08**	.13***	0.02	0.06
32. AtTuteABC	.17***	.25***	.18***	.15***	.15***	.15***	.15***	.16***	.13***	.15***	.10***	.14***	.11***	.16***	.08**	.11***
33. AtTuteCVP	.16***	.21***	.17***	.18***	.15***	.10***	.14***	.17***	.12***	.12***	.07**	.07**	.08**	.11***	0.05	.09**
34. AtTuteDM	.19***	.25***	.20***	.18***	.17***	.19***	.17***	.20***	.11***	.14***	.13***	.12***	.12***	.13***	.11***	.13***
35. HWStudent	.16***	.19***	.12***	.14***	.11***	.07***	.07***	.12***	.09***	.12***	.08***	.07**	.08**	.12***	.09**	.08**
36. FirstSemUni	.07***	.09***	.19***	.12***	.12***	.08***	.10***	.11***	.07***	.10***	.13***	.13***	.16***	.14***	.10***	.09**
37. EAL	-.06**	-.07***	-.10***	-.10***	-.11***	-0.04	-.14***	-.14***	-0.02	0.01	0.02	0.03	-0.02	-0.03	0	0.01
38. AccMaj	0.03	.05**	0.02	.05**	0.03	.06**	0.03	0.01	0.02	0	0.05	0.01	0	.08**	0.04	0.06
39. Repeat	-.08***	-.10***	-.13***	-.10***	-.10***	-.10***	-.10***	-.13***	-0.05	-.07***	-.09***	-.09***	-.13***	-.10***	-.12***	-.09***

Note: *p<0.1; **p<0.05; ***p<0.01

Light grey items do not appear in the same regression models, so are not relevant to the analysis.

Table 4. Pearson Correlation Matrix

Variable	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
18. OnQuizJournalUse	0.02															
19. OnQuizAdjJnlUse	0.03	.73***														
20. OnQuizAdjCalcUse	.08**	.61***	.71***													
21. OnQuizCloseUse	.16***	.55***	.60***	.68***												
22. OnQuizInvUse	.16***	.43***	.48***	.46***	.50***											
23. OnQuizNotesRecUse	.12***	.53***	.59***	.55***	.60***	.58***										
24. OnQuizABCUse	.14***	.40***	.43***	.41***	.45***	.60***	.47***									
25. OnQuizCVPUse	.18***	.39***	.42***	.43***	.43***	.59***	.45***	.73***								
26. OnQuizDMUse	NA	.36***	.40***	.40***	.43***	.58***	.46***	.70***	.79***							
27. WAMExAccA	.28***	.32***	.33***	.31***	.33***	.30***	.32***	.30***	.29***	.28***						
28. AtTuteJournal	.10***	.11***	.11***	.11***	.10***	.10***	.12***	.09***	.09***	.08***	.25***					
29. AtTuteAdjClose	.11***	.14***	.16***	.16***	.13***	.14***	.14***	.08***	.10***	.08***	.26***	.54***				
30. AtTuteInvCostFlow	0.02	.13***	.17***	.14***	.13***	.16***	.16***	.13***	.13***	.15***	.31***	.47***	.43***			
31. AtTuteReceivable	.11***	.14***	.15***	.14***	.13***	.13***	.14***	.11***	.12***	.11***	.24***	.53***	.49***	.46***		
32. AtTuteABC	.11***	.18***	.19***	.18***	.17***	.17***	.18***	.15***	.15***	.13***	.28***	.48***	.51***	.46***	.54***	
33. AtTuteCVP	.12***	.16***	.16***	.17***	.15***	.14***	.15***	.10***	.13***	.13***	.28***	.48***	.46***	.43***	.52***	.56***
34. AtTuteDM	.16***	.19***	.20***	.18***	.18***	.17***	.21***	.15***	.16***	.17***	.29***	.41***	.41***	.39***	.49***	.52***
35. HWStudent	0.05	.11***	.11***	.13***	.11***	.10***	.13***	.06**	.08***	.07***	.22***	.62***	.51***	.43***	.55***	.57***
36. FirstSemUni	.19***	.13***	.13***	.12***	.15***	.11***	.12***	.07***	.09***	.07***	.27***	.16***	.22***	.18***	.16***	.17***
37. EAL	-0.05	-.10***	-.13***	-.07***	-.10***	-.07***	-.08***	-.11***	-.09***	-.09***	-.15***	0.01	0.01	-0.02	-0.02	0.01
38. AccMaj	0.05	-0.02	-0.02	-0.03	0	0	0	0	-0.01	-0.01	-0.03	-0.02	-0.01	-0.02	0	-0.01
39. Repeat	-.09**	-.13***	-.12***	-.12***	-.13***	-.14***	-.13***	-.11***	-.11***	-.13***	-.27***	-.14***	-.16***	-.15***	-.14***	-.12***

Note: *p<0.1; **p<0.05; ***p<0.01

Light grey items do not appear in the same regression models, so are not relevant to the analysis.

Variable	33	34	35	36	37	38
34. AtTuteDM	.55***					
35. HWStudent	.57***	.48***				
36. FirstSemUni	.17***	.16***	0.02			
37. EAL	-0.02	-0.01	0.02	-.16***		
38. AccMaj	-0.02	-0.02	0.01	-.13***	.07***	
39. Repeat	-.14***	-.15***	-.07***	-.37***	0.04	0

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5. Association Between Online Quiz Use and Exam Performance on the Related Topic

Panel A:

	Dependent variable:			
	MSExJournal	MSExAdjust	EndExClose	EndExInv
OnQuizJournalUse	**0.135*****			
	(0.014)			
OnQuizAdjJnlUse		**0.098*****		
		(0.018)		
OnQuizAdjCalcUse		**0.103*****		
		(0.017)		
OnQuizCloseUse			**0.193*****	
			(0.017)	
OnQuizInvUse				**0.155*****
				(0.012)
AtTuteJournal	-0.018			
	(0.021)			
AtTuteAdjClose		0.040**	0.051**	
		(0.017)	(0.024)	
AtTuteInvCostFlow				0.068***
				(0.016)
HWStudent	0.050***	0.044***	0.013	0.013
	(0.017)	(0.015)	(0.021)	(0.014)
FirstSemUni	-0.022	-0.018	0.045**	-0.004
	(0.014)	(0.013)	(0.019)	(0.013)
WAMExAccA	0.012***	0.011***	0.011***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
EAL	0.01	0.005	-0.014	-0.021*
	(0.013)	(0.012)	(0.017)	(0.012)
AccMaj	0.041**	0.059***	0.042	0.052***
	(0.020)	(0.019)	(0.026)	(0.018)
Repeat	0.061***	0.050**	0.024	0.029
	(0.023)	(0.022)	(0.030)	(0.021)
Constant	-0.237***	-0.323***	-0.552***	-0.106***
	(0.040)	(0.038)	(0.054)	(0.038)
Observations	1,832	1,798	1,830	1,866
R^2	0.274	0.337	0.241	0.249
Adjusted R^2	0.271	0.333	0.237	0.246
Residual Std. Error	0.260	0.245	0.345	0.244
F Statistic	86.030***	100.796***	72.202***	77.079***

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

Table 5. Association Between Online Quiz Use and Exam Performance on the Related Topic

Panel B:

	Dependent variable:			
	EndExReceive	EndExABC	EndExCVP	EndExDM
OnQuizNotesRecUse	**0.185*****			
	(0.017)			
OnQuizABCUse		**0.254*****		
		(0.015)		
OnQuizCVPUse			**0.170*****	
			(0.016)	
OnQuizDMUse				**0.172*****
				(0.014)
AtTuteReceivable	0.036			
	(0.023)			
AtTuteABC		0.032*		
		(0.019)		
AtTuteCVP			0.03	
			(0.020)	
AtTuteDM				0.039**
				(0.015)
HWStudent	0.013	-0.014	-0.021	0.012
	(0.021)	(0.019)	(0.020)	(0.016)
FirstSemUni	0.01	-0.015	-0.02	-0.013
	(0.018)	(0.016)	(0.017)	(0.014)
WAMExAccA	0.010***	0.008***	0.011***	0.009***
	(0.001)	(0.001)	(0.001)	(0.001)
EAL	-0.032*	0.021	-0.057***	-0.046***
	(0.016)	(0.014)	(0.015)	(0.013)
AccMaj	0.050*	0.062***	0.060**	0.023
	(0.026)	(0.022)	(0.024)	(0.021)
Repeat	0.041	0.014	0.015	-0.002
	(0.030)	(0.026)	(0.028)	(0.024)
Constant	-0.425***	-0.350***	-0.312***	-0.284***
	(0.054)	(0.046)	(0.050)	(0.043)
Observations	1,728	1,833	1,798	1,868
R^2	0.209	0.264	0.237	0.254
Adjusted R^2	0.205	0.261	0.234	0.251
Residual Std. Error	0.324	0.295	0.312	0.273
F Statistic	56.782***	81.989***	69.626***	79.149***

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

Table 6. Comparison Between Exam Performance and the Magnitude of the Coefficient of Association Between Online Quiz Use and Exam Performance on the Related Topic

Topic	Exam performance		Quiz use coefficient	
Activity based costing	33%	(most difficult)	0.254	(highest coefficient)
Closing entries	35%		0.193	
Receivables	37%		0.185	
Decision making	40%		0.172	
Cost volume profit analysis	47%		0.170	
Inventory	52%		0.155	
Adjusting entries	57%		0.103[a]	
			0.098[b]	(lowest coefficient)
Journal entries	66%	(least difficult)	0.135	

[a] Calculating adjusting entries quiz
[b] Journalising adjusting entries quiz

Table 7. Association Between Online Quiz Performance and Exam Performance on the Related Topic

Panel A:

	Dependent variable:			
	MSExJournal	MSExAdjust	EndExClose	EndExInv
OnQuizJournalPerf	**0.525*****			
	(0.032)			
OnQuizAdjJnlPerf		**0.199*****		
		(0.031)		
OnQuizAdjCalcPerf		**0.182*****		
		(0.027)		
OnQuizClosePerf			**0.300*****	
			(0.035)	
OnQuizInvPerf				**0.235*****
				(0.025)
AtTuteJournal	-0.017			
	(0.023)			
AtTuteAdjClose		0.031	0.082**	
		(0.023)	(0.039)	
AtTuteInvCostFlow				0.053**
				(0.026)
HWStudent	0.002	0.029	-0.015	-0.012
	(0.018)	(0.019)	(0.034)	(0.021)
FirstSemUni	-0.019	-0.033**	0.017	-0.022
	(0.015)	(0.016)	(0.029)	(0.019)
WAMExAccA	0.008***	0.008***	0.012***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
EAL	0.005	-0.014	-0.03	-0.031*
	(0.013)	(0.015)	(0.026)	(0.018)
AccMaj	0.03	0.052**	0.077**	0.017
	(0.021)	(0.024)	(0.039)	(0.027)
Repeat	0.045*	0.043	-0.005	-0.03
	(0.027)	(0.030)	(0.056)	(0.041)
Constant	-0.252***	-0.166***	-0.520***	0.043
	(0.049)	(0.055)	(0.097)	(0.068)
Observations	1,312	1,034	917	858
R^2	0.304	0.301	0.212	0.200
Adjusted R^2	0.300	0.295	0.205	0.192
Residual Std. Error	0.228	0.225	0.363	0.248
F Statistic	71.224***	49.067***	30.497***	26.455***

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

Table 7. Association Between Online Quiz Performance and Exam Performance on the Related Topic

Panel B:

	Dependent variable:			
	EndExReceive	EndExABC	EndExCVP	EndExDM
OnQuizNotesRecPerf	**0.283*****			
	(0.035)			
OnQuizABCPerf		**0.343*****		
		(0.027)		
OnQuizCVPPerf			**0.300*****	
			(0.032)	
OnQuizDMPerf				**0.241*****
				(0.032)
AtTuteReceivable	0.043			
	(0.034)			
AtTuteABC		-0.007		
		(0.031)		
AtTuteCVP			0.04	
			(0.031)	
AtTuteDM				0.018
				(0.029)
HWStudent	-0.004	-0.02	-0.046	-0.004
	(0.030)	(0.029)	(0.031)	(0.030)
FirstSemUni	-0.016	-0.045*	-0.015	-0.042*
	(0.025)	(0.024)	(0.025)	(0.025)
WAMExAccA	0.009***	0.010***	0.009***	0.010***
	(0.001)	(0.001)	(0.001)	(0.001)
EAL	-0.015	0.014	-0.052**	-0.027
	(0.022)	(0.022)	(0.023)	(0.024)
AccMaj	0.027	0.039	0.060*	0.025
	(0.035)	(0.033)	(0.035)	(0.036)
Repeat	0.036	0.012	0.01	-0.016
	(0.051)	(0.048)	(0.050)	(0.056)
Constant	-0.337***	-0.323***	-0.145	-0.267***
	(0.085)	(0.087)	(0.090)	(0.089)
Observations	999	762	760	695
R^2	0.157	0.293	0.222	0.203
Adjusted R^2	0.150	0.286	0.213	0.194
Residual Std. Error	0.336	0.289	0.296	0.294
F Statistic	22.992***	39.010***	26.720***	21.892***

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

Table 8. Piecewise regression – self-test or worked example

Panel A:

	Online Quiz Topic / Dependent variable:			
	MSExJournal	MSExAdjust Journal Quiz	MSExAdjust Calc Quiz	EndExClose
OnQuizPerf	-0.208	0.104	**0.242*****	**0.475*****
	(0.150)	(0.127)	**(0.062)**	**(0.112)**
OnQuizPerf*QzPass	**0.980*****	0.091	**-0.149***	**-0.366****
	(0.159)	(0.136)	**(0.088)**	**(0.154)**
QzPass	-0.471***	-0.016	0.081	0.197**
	(0.066)	(0.057)	(0.051)	(0.096)
AtTute	-0.009	0.031	0.03	0.078**
	(0.022)	(0.023)	(0.023)	(0.039)
OnQuizAdjJnlPerf			0.196***	
			(0.031)	
OnQuizAdjCalcPerf		0.183***		
		(0.027)		
HWStudent	-0.002	0.029	0.029	-0.01
	(0.018)	(0.019)	(0.019)	(0.034)
FirstSemUni	-0.019	-0.033**	-0.033**	0.018
	(0.014)	(0.016)	(0.016)	(0.028)
WAMExAccA	0.007***	0.008***	0.008***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)
EAL	0.004	-0.014	-0.014	-0.027
	(0.013)	(0.015)	(0.015)	(0.026)
AccMaj	0.03	0.051**	0.052**	0.080**
	(0.020)	(0.024)	(0.024)	(0.039)
Repeat	0.038	0.042	0.043	-0.004
	(0.026)	(0.030)	(0.030)	(0.056)
Constant	0.059	-0.142**	-0.181***	-0.551***
	(0.067)	(0.065)	(0.056)	(0.098)
Observations	1,312	1,034	1,034	917
R^2	0.330	0.302	0.303	0.217
Adjusted R^2	0.325	0.294	0.296	0.208
Residual Std. Error	0.224	0.225	0.225	0.362
F Statistic	64.223***	40.153***	40.450***	25.062***

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

Table 8. Piecewise regression – self-test or worked example

Panel B:

	Online Quiz Topic / Dependent variable:				
	EndExInv	EndExReceive	EndExABC	EndExCVP	EndExDM
OnQuizPerf	0.043	0.150	**0.428*****	**0.310****	**0.358*****
	(0.081)	(0.123)	**(0.100)**	**(0.139)**	**(0.094)**
OnQuizPerf*QzPass	**0.180***	0.232	-0.062	-0.132	-0.113
	(0.107)	(0.145)	(0.139)	(0.155)	(0.133)
QzPass	-0.012	-0.119	-0.018	0.118*	0.005
	(0.063)	(0.076)	(0.084)	(0.062)	(0.084)
AtTute	0.054**	0.043	-0.008	0.043	0.019
	(0.026)	(0.034)	(0.031)	(0.031)	(0.029)
HWStudent	-0.015	-0.005	-0.02	-0.048	-0.002
	(0.021)	(0.030)	(0.029)	(0.031)	(0.030)
FirstSemUni	-0.023	-0.013	-0.045*	-0.016	-0.039
	(0.019)	(0.025)	(0.024)	(0.025)	(0.025)
WAMExAccA	0.006***	0.009***	0.010***	0.009***	0.010***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
EAL	-0.032*	-0.017	0.014	-0.051**	-0.028
	(0.018)	(0.022)	(0.022)	(0.023)	(0.024)
AccMaj	0.018	0.027	0.041	0.066*	0.026
	(0.027)	(0.035)	(0.034)	(0.035)	(0.036)
Repeat	-0.036	0.038	0.01	0.015	-0.018
	(0.041)	(0.051)	(0.048)	(0.050)	(0.056)
Constant	0.079	-0.293***	-0.327***	-0.166*	-0.272***
	(0.070)	(0.089)	(0.087)	(0.091)	(0.089)
Observations	858	999	762	760	695
R^2	0.206	0.159	0.294	0.226	0.205
Adjusted R^2	0.196	0.151	0.284	0.215	0.194
Residual Std. Error	0.247	0.336	0.289	0.296	0.294
F Statistic	21.924***	18.687***	31.250***	21.820***	17.688***

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

Table 9. First-Stage Prediction Models for Propensity Score Matching

Panel A:

	Dependent variable:				
	OnQuizJournalUse	OnQuizAdjJnlUse	OnQuizAdjCalcUse	OnQuizCloseUse	OnQuizInvUse
AtTuteJournal	0.016				
	(0.177)				
AtTuteAdjClose		0.367**	0.309**	0.177	
		(0.150)	(0.142)	(0.145)	
AtTuteInvCostFlow					0.417***
					(0.139)
HWStudent	0.2	0.087	0.178	0.145	0.04
	(0.150)	(0.139)	(0.128)	(0.129)	(0.120)
FirstSemUni	0.141	0.094	0.063	0.172	-0.002
	(0.121)	(0.124)	(0.113)	(0.113)	(0.110)
WAMExAccA	0.058***	0.059***	0.054***	0.062***	0.053***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)
EAL	-0.237**	-0.427***	-0.118	-0.223**	-0.087
	(0.110)	(0.112)	(0.102)	(0.103)	(0.101)
AccMaj	-0.037	-0.013	-0.155	0.12	0.084
	(0.170)	(0.173)	(0.158)	(0.160)	(0.157)
Repeat	-0.232	-0.081	-0.113	-0.167	-0.437**
	(0.179)	(0.183)	(0.180)	(0.191)	(0.197)
Constant	-2.959***	-3.088***	-3.584***	-4.371***	-3.983***
	(0.357)	(0.362)	(0.356)	(0.376)	(0.366)
Observations	1,900	1,864	1,864	1,864	1,900
Log Likelihood	-1,040.43	-1,004.50	-1,169.07	-1,168.13	-1,207.00
Akaike Inf. Crit.	2,096.87	2,024.99	2,354.14	2,352.26	2,430.00

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

Table 9. First-Stage Prediction Models for Propensity Score Matching

Panel B:

	Dependent variable:			
	OnQuizNotesRecUse	OnQuizABCUse	OnQuizCVPUse	OnQuizDMUse
AtTuteReceivable	0.217			
	(0.148)			
AtTuteABC		0.587***		
		(0.140)		
AtTuteCVP			0.22	
			-0.137	
AtTuteDM				0.505***
				-0.124
HWStudent	0.222	-0.317**	-0.006	-0.155
	(0.136)	(0.138)	(0.139)	(0.131)
FirstSemUni	0.112	-0.257**	-0.089	-0.266**
	(0.116)	(0.115)	(0.115)	(0.114)
WAMExAccA	0.055***	0.060***	0.062***	0.054***
	(0.005)	(0.006)	(0.006)	(0.006)
EAL	-0.113	-0.318***	-0.183*	-0.254**
	(0.106)	(0.105)	(0.105)	(0.105)
AccMaj	0.135	0.131	0.065	0.005
	(0.167)	(0.162)	(0.163)	(0.163)
Repeat	-0.297	-0.313	-0.237	-0.565***
	(0.195)	(0.201)	(0.202)	(0.217)
Constant	-3.677***	-4.294***	-4.457***	-4.066***
	(0.375)	(0.386)	(0.391)	(0.385)
Observations	1,759	1,863	1,828	1,900
Log Likelihood	-1,103.07	-1,150.56	-1,140.68	-1,148.13
Akaike Inf. Crit.	2,222.15	2,317.12	2,297.36	2,312.25

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

Table 10. Univariate Analysis of Matched Sample Using Propensity Score Matching

Panel A: Journal Entry Quiz Use

Covariate	Mean control (no quiz use)	Mean treated (quiz use)	Difference	t-statistic
AtTuteJournal	0.792	0.800	-0.008	-0.314
HWStudent	0.682	0.662	0.020	0.673
FirstSemUni	0.492	0.480	0.012	0.379
WAMExAccA	61.927	64.127	-2.200***	-3.188
EAL	0.488	0.424	0.064**	2.034
AccMaj	0.120	0.128	-0.008	-0.383
Repeat	0.150	0.122	0.028	1.291
Number of matches	500	500		

Note: *p<0.1; **p<0.05; ***p<0.01

Panel B: Adjusting Entries Journal Entry Quiz Use

Covariate	Mean control (no quiz use)	Mean treated (quiz use)	Difference	t-statistic
AtTuteAdjClose	0.718	0.716	0.002	0.071
HWStudent	0.677	0.675	0.002	0.068
FirstSemUni	0.498	0.545	-0.047	-1.477
WAMExAccA	61.398	63.584	-2.186***	-3.108
EAL	0.523	0.481	0.041	1.283
AccMaj	0.119	0.109	0.010	0.504
Repeat	0.146	0.123	0.023	1.033
Number of matches	486	486		

Note: *p<0.1; **p<0.05; ***p<0.01

Panel C: Adjusting Entries Calculation Quiz Use

Covariate	Mean control (no quiz use)	Mean treated (quiz use)	Difference	t-statistic
AtTuteAdjClose	0.765	0.806	-0.042*	-1.863
HWStudent	0.705	0.739	-0.034	-1.401
FirstSemUni	0.542	0.554	-0.012	-0.439
WAMExAccA	64.279	66.093	-1.814***	-3.309
EAL	0.452	0.446	0.006	0.219
AccMaj	0.116	0.116	0.000	0.000
Repeat	0.109	0.098	0.010	0.627
Number of matches	671	671		

Note: *p<0.1; **p<0.05; ***p<0.01

Table 10. Univariate Analysis of Matched Sample Using Propensity Score Matching

Panel D: Closing Entry Quiz Use

Covariate	Mean control (no quiz use)	Mean treated (quiz use)	Difference	t-statistic
AtTuteAdjClose	0.795	0.803	-0.008	-0.397
HWStudent	0.721	0.728	-0.007	-0.296
FirstSemUni	0.565	0.590	-0.025	-0.965
WAMExAccA	66.061	67.460	-1.400***	-2.916
EAL	0.417	0.420	-0.003	-0.107
AccMaj	0.104	0.122	-0.018	-1.088
Repeat	0.090	0.076	0.014	0.961
Number of matches	712	712		

Note: *p<0.1; **p<0.05; ***p<0.01

Panel E: Inventory Journal Entry Quiz Use

Covariate	Mean control (no quiz use)	Mean treated (quiz use)	Difference	t-statistic
AtTuteInvCostFlow	0.836	0.845	-0.008	-0.424
HWStudent	0.751	0.740	0.011	0.475
FirstSemUni	0.607	0.617	-0.009	-0.372
WAMExAccA	66.979	68.458	-1.479***	-3.076
EAL	0.412	0.409	0.003	0.105
AccMaj	0.114	0.106	0.008	0.496
Repeat	0.048	0.060	-0.012	-1.028
Number of matches	746	746		

Note: *p<0.1; **p<0.05; ***p<0.01

Panel F: Receivables Journal Entry Quiz Use

Covariate	Mean control (no quiz use)	Mean treated (quiz use)	Difference	t-statistic
AtTuteReceivable	0.753	0.773	-0.020	-0.841
HWStudent	0.707	0.713	-0.006	-0.242
FirstSemUni	0.546	0.569	-0.023	-0.830
WAMExAccA	64.645	66.621	-1.976***	-3.707
EAL	0.439	0.443	-0.005	-0.166
AccMaj	0.104	0.101	0.003	0.181
Repeat	0.101	0.085	0.017	1.041
Number of matches	661	661		

Note: *p<0.1; **p<0.05; ***p<0.01

Table 10. Univariate Analysis of Matched Sample Using Propensity Score Matching

Panel G: Activity Based Costing Quiz Use

Covariate	Mean control (no quiz use)	Mean treated (quiz use)	Difference	t-statistic
AtTuteABC	0.750	0.776	-0.026	-1.131
HWStudent	0.737	0.743	-0.006	-0.244
FirstSemUni	0.623	0.613	0.010	0.385
WAMExAccA	68.145	69.156	-1.011**	-2.114
EAL	0.369	0.371	-0.003	-0.111
AccMaj	0.109	0.117	-0.009	-0.506
Repeat	0.053	0.061	-0.009	-0.690
Number of matches	700	700		

Note: *p<0.1; **p<0.05; ***p<0.01

Panel H: Cost Volume Profit Analysis Quiz Use

Covariate	Mean control (no quiz use)	Mean treated (quiz use)	Difference	t-statistic
AtTuteCVP	0.731	0.745	-0.014	-0.608
HWStudent	0.747	0.758	-0.011	-0.495
FirstSemUni	0.617	0.627	-0.010	-0.386
WAMExAccA	68.237	69.421	-1.184**	-2.482
EAL	0.366	0.371	-0.004	-0.166
AccMaj	0.114	0.113	0.001	0.084
Repeat	0.060	0.063	-0.003	-0.222
Number of matches	699	699		

Note: *p<0.1; **p<0.05; ***p<0.01

Panel I: Decision Making Quiz Use

Covariate	Mean control (no quiz use)	Mean treated (quiz use)	Difference	t-statistic
AtTuteDM	0.709	0.712	-0.003	-0.119
HWStudent	0.752	0.756	-0.004	-0.189
FirstSemUni	0.620	0.621	-0.001	-0.056
WAMExAccA	68.983	69.670	-0.687	-1.387
EAL	0.370	0.358	0.012	0.450
AccMaj	0.103	0.107	-0.004	-0.265
Repeat	0.046	0.048	-0.003	-0.256
Number of matches	681	681		

Note: *p<0.1; **p<0.05; ***p<0.01

Table 11. Second Stage Propensity Score Matching Models With 0.2 Caliper

Panel A:

	Dependent variable:				
	MSExJournal	MSExAdjust	MSExAdjust	EndExClose	EndExInv
OnQuizJournalUse	**0.141*****				
	(0.018)				
OnQuizAdjJnlUse		**0.177*****			
		(0.017)			
OnQuizAdjCalcUse			**0.166*****		
			(0.014)		
OnQuizCloseUse				**0.187*****	
				(0.019)	
OnQuizInvUse					**0.155*****
					(0.013)
AtTuteJournal	-0.035				
	(0.028)				
AtTuteAdjClose		0.033	0.042**	0.052*	
		(0.022)	(0.020)	(0.028)	
AtTuteInvCostFlow					0.069***
					(0.019)
HWStudent	0.065***	0.041**	0.042**	0.02	0.008
	(0.024)	(0.021)	(0.018)	(0.024)	(0.016)
FirstSemUni	-0.019	-0.001	-0.02	0.035*	-0.012
	(0.020)	(0.019)	(0.015)	(0.021)	(0.014)
WAMExAccA	0.013***	0.010***	0.012***	0.013***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
EAL	0.008	0.030*	0.017	-0.012	-0.02
	(0.018)	(0.017)	(0.014)	(0.019)	(0.013)
AccMaj	0.045*	0.046*	0.049**	0.039	0.062***
	(0.027)	(0.026)	(0.021)	(0.030)	(0.021)
Repeat	0.059**	0.058**	0.050**	0.034	-0.004
	(0.028)	(0.027)	(0.024)	(0.037)	(0.030)
Constant	-0.294***	-0.330***	-0.379***	-0.703***	-0.115**
	(0.058)	(0.052)	(0.049)	(0.075)	(0.051)
Observations	1,000	972	1,342	1,424	1,492
R^2	0.253	0.272	0.283	0.182	0.185
Adjusted R^2	0.247	0.266	0.278	0.177	0.18
Residual Std. Error	0.276	0.256	0.249	0.354	0.246
F Statistic	41.861***	44.996***	65.632***	39.329***	41.961***

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

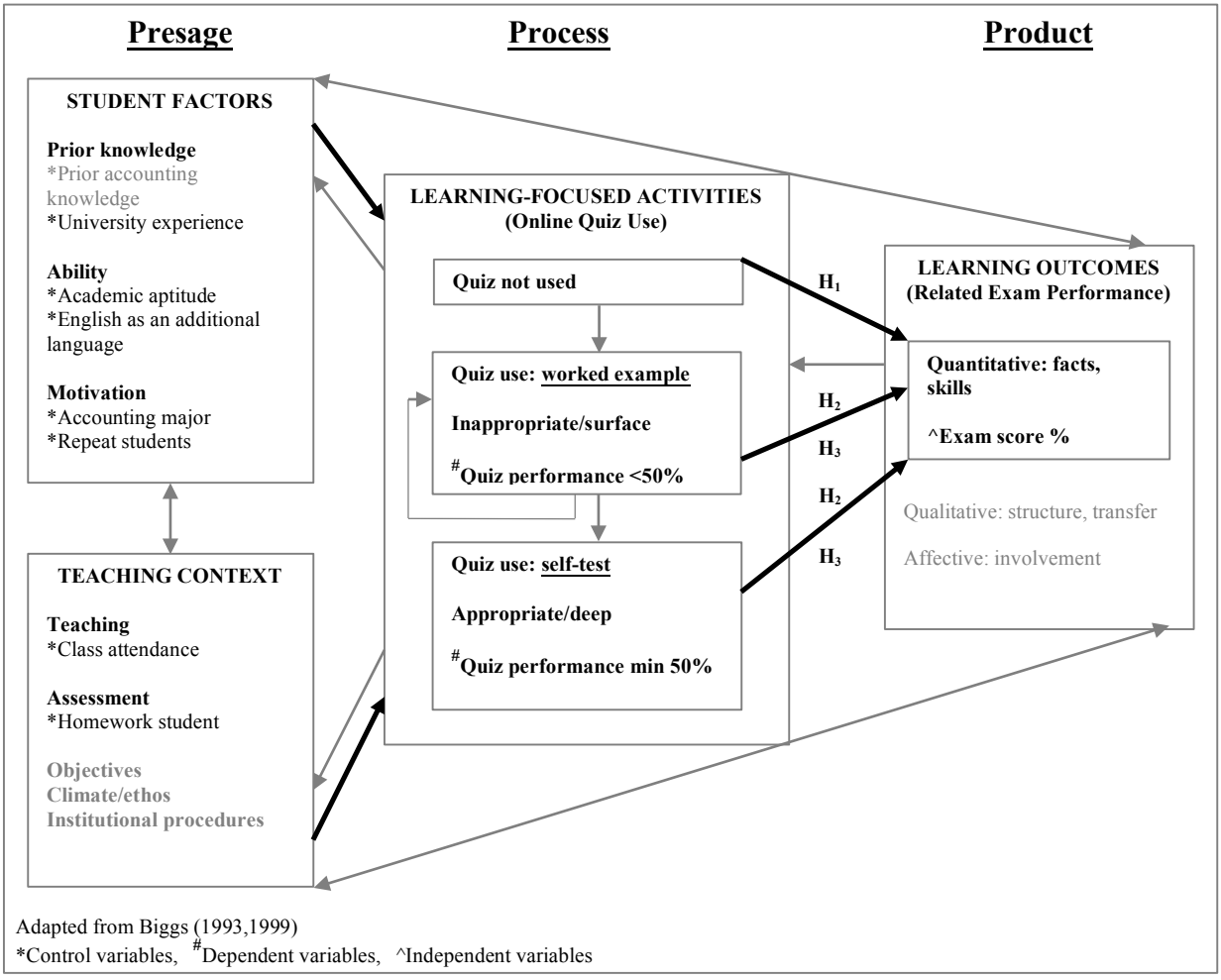
Table 11. Second Stage Propensity Score Matching Models

Panel B:

	Dependent variable:			
	EndExReceive	EndExABC	EndExCVP	EndExDM
OnQuizNotesRecUse	**0.182*****			
	(0.018)			
OnQuizABCUse		**0.259*****		
		(0.016)		
OnQuizCVPUse			**0.173*****	
			(0.017)	
OnQuizDMUse				**0.170*****
				(0.016)
AtTuteReceivable	0.048*			
	(0.025)			
AtTuteABC		0.026		
		(0.023)		
AtTuteCVP			0.039*	
			(0.023)	
AtTuteDM				0.052***
				(0.020)
HWStudent	0.006	-0.008	-0.034	0.004
	(0.023)	(0.022)	(0.024)	(0.021)
FirstSemUni	-0.015	-0.034*	-0.03	-0.024
	(0.020)	(0.019)	(0.020)	(0.018)
WAMExAccA	0.011***	0.011***	0.013***	0.010***
	(0.001)	(0.001)	(0.001)	(0.001)
EAL	-0.019	0.023	-0.044**	-0.053***
	(0.018)	(0.017)	(0.018)	(0.016)
AccMaj	0.029	0.091***	0.070***	0.021
	(0.029)	(0.026)	(0.027)	(0.026)
Repeat	0.035	-0.019	0.016	-0.016
	(0.033)	(0.038)	(0.038)	(0.039)
Constant	-0.511***	-0.496***	-0.446***	-0.353***
	(0.066)	(0.067)	(0.071)	(0.064)
Observations	1,322	1,400	1,398	1,362
R^2	0.182	0.233	0.188	0.185
Adjusted R^2	0.177	0.229	0.183	0.181
Residual Std. Error	0.32	0.304	0.317	0.288
F Statistic	36.424***	52.798***	40.119***	38.498***

Note: *p<0.1; **p<0.05; ***p<0.01 Standard errors are reported below each regression coefficient.

Figure 1. Modified 3P Model



Adapted from Biggs (1993,1999)
*Control variables, #Dependent variables, ^Independent variables

Figure 2. Example Exam Question on Providing Services to a Customer on Credit

1. Billed (invoiced) a client $7,000 for design services provided during January.

GENERAL JOURNAL – Transaction			
Date	**Account Names**	**$**	**$**
Jan. 1			

Figure 3. Online Quiz Question on Providing Services to a Customer on Credit

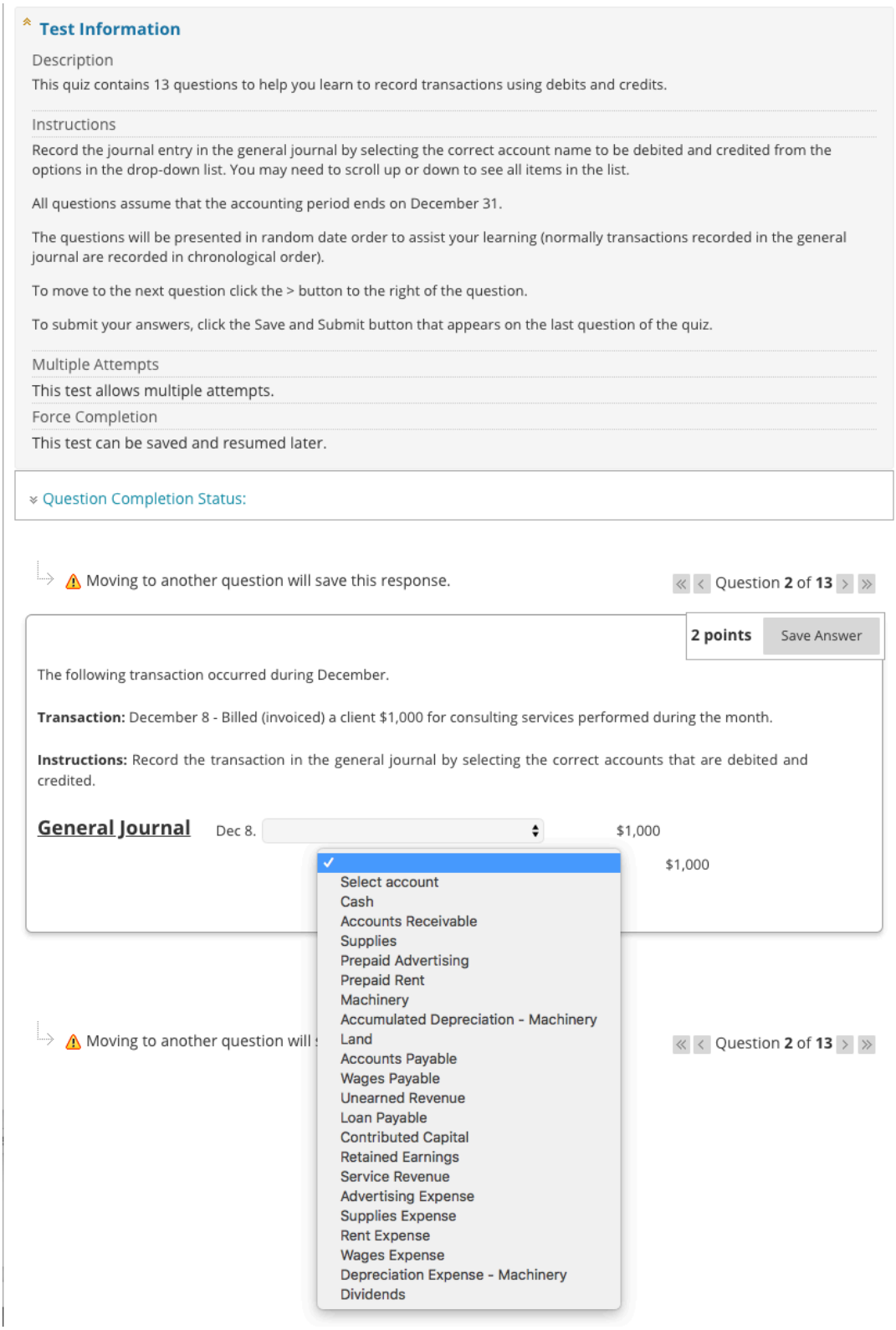


Figure 4. Feedback From Learning Quiz Question on Providing Services to a Customer on Credit

Question 2 1 out of 2 points

The following transaction occurred during December.

Transaction: December 8 - Billed (invoiced) a client $1,000 for consulting services performed during the month.

Instructions: Record the transaction in the general journal by selecting the correct accounts that are debited and credited.

General Journal

Dec 8. **[A]** $1,000

[B] $1,000

Selected Answer:

The following transaction occurred during December.

Transaction: December 8 - Billed (invoiced) a client $1,000 for consulting services performed during the month.

Instructions: Record the transaction in the general journal by selecting the correct accounts that are debited and credited.

General Journal

Dec 8. **Accounts Receivable** $1,000

Contributed Capital $1,000

Answers:

The following transaction occurred during December.

Transaction: December 8 - Billed (invoiced) a client $1,000 for consulting services performed during the month.

Instructions: Record the transaction in the general journal by selecting the correct accounts that are debited and credited.

General Journal

Dec 8. **Accounts Receivable** $1,000

Service Revenue $1,000

All Answer Choices

- Select account
- Cash
- Accounts Receivable
- Supplies
- Prepaid Advertising
- Prepaid Rent
- Machinery
- Accumulated Depreciation - Machinery
- Land
- Accounts Payable
- Wages Payable
- Unearned Revenue
- Loan Payable
- Contributed Capital
- Retained Earnings
- Service Revenue
- Advertising Expense
- Supplies Expense
- Rent Expense
- Wages Expense
- Depreciation Expense - Machinery
- Dividends

Response Feedback: This is not correct. When the business performs services for a customer and bills the client, it means that the business does not receive the cash immediately. Instead, the cash will be received at a later date. The Accounts Receivable of the business increases and the business can now recognise the revenue because it has been earned in the accounting period.

Accounts Receivable is an asset with a normal debit balance. Since the amount receivable increases, the Accounts Receivable account is debited.

Service Revenue is a revenue account with a normal credit balance. Since the revenue earned has increased, Service Revenue is credited.

Remember:

- The normal balance shows the side of the account (debit or credit) where an increase is recorded. So decreases are recorded on the opposite side to the normal balance.
- When recording transactions in the general journal, the account debited is always above the account credited.
- If there is more than one account debited or credited in a single transaction, all of the debited accounts appear above all of the credited accounts.