ADVANTAGES AND DISADVANTAGES OF AN INNOVATIVE TABLET TECHNOLOGY LEARNING ACTIVITY: A TEN YEAR CASE STUDY IN SMALL TERTIARY MATHEMATICS CLASSROOMS

Daphne Robson*	Ara Institute of Canterbury, Christchurch, New Zealand	Daphne.Robson@ara.ac.nz
Britta Basse	Ara Institute of Canterbury, Christchurch, New Zealand	Britta.Basse@ara.ac.nz

* Corresponding author

ABSTRACT

Aim/Purpose	To identify positive and negative aspects for learning of interactive tablet technology learning activities that promote student engagement and learning.
Background	Engaging students in mathematics classes is an on-going challenge for teachers.
	In 2008 we were offered the opportunity to run interactive activities with a class set of tablet PCs that had just been released on to the market. Since then, we have run these interactive activities continuously with mathematics classes for computing students, albeit with two changes in hardware.
Methodology	In the interactive activities, students submit full worked solutions to various problem types (classified as table, text, open or multi-choice) which can then be displayed to the class anonymously, discussed and annotated by the teacher. We surveyed student and staff perceptions and monitored academic performance.
Contribution	We have over 10 years of results, observations, and experience from 2008, when tablet technologies were new and expensive, to the current time, when modern tablets with styli are now affordable.
Findings	There was a significant increase in higher grades although pass rates did not increase significantly. Over the ten year period of the study, perceptions of students and staff about how this technology impacted on student learning were consistently positive. The majority of students found all problem types useful

for learning even those they rated "too hard" or "too easy". Benefits included increased feedback, peer learning and engagement.

Recommendations for Practitioners	We recommend using tablet learning activities to engage students and teachers and to contribute to learning.
Impact on Society	This study shows how using tablet technologies for interactive classroom activities can enable and enhance known pedagogies of feedback, peer instruction, and student engagement for mathematics classes.
Future Research	We recommend extending this study to include larger classes, and other technical subjects that use symbols and diagrams. In addition, we suggest considering control groups.
Keywords	interactive, engagement, achievement, digital ink, feedback

INTRODUCTION AND THEORETICAL BACKGROUND

> "In my personal opinion, it was the most effective class education
> I've ever studied. The best. Period." – Student participant.

Worldwide, large numbers of computers were introduced into education in the 1980s and since then there has been an ongoing evolution in the way computers are used in schools and tertiary institutions. These changes comprise four main stages: "computer-based instruction"; "stand-alone multimedia learning"; "collaborative learning with networked computers"; and "online learning in a digital age" (Zawacki-Richter & Latchem, 2018). During this time, research questions have progressed from "Can using computers improve learning?" to "How can using computers improve learning?" with a current research focus being how computers can facilitate student self-constructed learning via feedback, interactivity, and problem solving (Zawacki-Richter & Latchem, 2018).

In this paper we present a ten-year study of a tablet-based interactive learning activity, which began at the end of the "collaborative learning with networked computers" stage and progressed through to the "online learning in a digital age" stage. In 2008 at the beginning of the study, tablet PCs with electronic styli (that allowed users to write directly on the screen with good quality digital ink) had recently become available but were not widely used as they were very expensive. Nowadays, tablets and larger smartphones with styli that allow good quality digital ink are readily available. Therefore, there is potential for the findings in this study to be widely applied.

The interactive learning activity in this study is based on the active learning activity with tablet PCs developed by Anderson et al. (2006), which in turn is based on Mazur's Peer Instruction (Mazur, 1997) with clickers. Both are designed to follow an introduction to a concept or a problem.

Mazur's Peer Instruction (1997) uses a sequence of steps that was originally trialed in physics lectures. Firstly, students receive a multi-choice question that requires them to apply their understanding of a concept to a problem. Mazur called these questions "ConcepTests". Students are given time to think and then record their answers on clickers. Then students talk to their neighbors with the goal of either convincing others about their answer or of modifying their understanding. Next, students resubmit an answer. Lastly, the teacher displays the student responses and conducts a class discussion of an explanation of the correct answer. Note that the term "Peer Instruction" refers to both Mazur's learning activity and to the pedagogies that underpin it (Mazur, 1997).

The active learning activity of Anderson et al. (2006) was based in computer science classes and involved a modification of Mazur's Peer Instruction (1997) that is possible when tablet PCs are used instead of clickers. The main differences are that questions are not limited to multi-choice, students can write their fully worked solutions directly onto the tablet PC, which the teacher can then select

for anonymous display to the whole class. Teachers can provide verbal feedback, annotate displayed solutions, and facilitate classroom discussion.

These modifications have the potential to offer additional learning benefits. Sharing a tablet PC and stylus encourages discussion about the question and embeds peer learning into the activity without allocating a separate time for this. Displaying a selection of students' fully worked solutions to the class allows the teacher to focus on reasons for each step and the underlying concepts, as well as consider different correct solution strategies relevant to students and point out common misconceptions.

The main theoretical ideas underpinning this study are social constructivism and Vygotsky's Zone of Proximal Development (Vygotsky, 1978). The interactive learning activity in this study allows students to construct their own learning, and provides scaffolding so that students can solve problems that they were unable to solve on their own. The scaffolding includes a contribution from peer learning and from teacher feedback. The peer learning also makes a social contribution to learning, an aspect which Vygotsky (1978) considered important. Furthermore, the feedback from the teacher in the teacher-led discussion stage of the activity moderates the peer learning.

In 2008, when the opportunity arose to use a class set of tablet PCs in small tertiary mathematics classrooms at Ara Institute of Canterbury, New Zealand, we were excited that incorporating this technology might help engage students. Since research shows that it is pedagogy that contributes to learning and not technology on its own (Clark, 1994; Russell, 2001; Sung & Mayer, 2013), we decided to follow Anderson et al.'s active learning activity using their Classroom Presenter software. We used this interactive learning activity in classes from 2008 to 2018 with a change to DyKnow Vision software in 2014 (Dyknow, 2015). During this time, we collected student performance data as well as survey data from both students and teachers. The objective of our research was to identify any positive or negative aspects for student learning.

Our research questions were:

1. What learning advantages and disadvantages are associated with an innovative tablet technology learning activity?
2. What were the student, teacher and observer perceptions of engagement, peer learning, and the feedback aspects of learning?

Over a ten-year time frame, we surveyed students, teachers, and observers about their perceptions of the impact that using the technology had on student learning. We surveyed students about the usefulness of different types of problems. We also compared student academic grade distributions before and after introducing the technology.

In this paper, we use the term "the technology" to refer to our combination of the interactive classroom activity and the hardware and software that enabled them. The term "digital ink" refers to writing directly on a screen with a stylus or electronic pen. We use the abbreviation "Mazur's PI" for Mazur's Peer Instruction (1997). We use the term "Anderson's active learning" to describe the learning activity in Anderson et al. (2006).

The contribution of this study is that it shares the learning of nearly a decade of experience using an interactive learning activity that has only recently become possible on readily available hardware. The length of this study has enabled us to explore the impact of the learning activity and the underlying pedagogies that essentially stayed the same during a period of changes in hardware, software and students' attitudes to technology.

LITERATURE REVIEW

Mazur's PI has been widely adopted in STEM subjects (science, technology, engineering, and mathematics). Many studies have supported its use citing improved outcomes, engagement, problem solv-

ing, and peer learning (e.g., Taylor et al., 2018). A thorough meta-study of research into the use of Mazur's PI activity in terms of the framework of pedagogies that underpin it was carried out by Vickrey, Rosploch, Rahmanian, Pilarz & Stains (2015). This meta-study identified a set of evidence based guidelines to inform teachers who modify Mazur's PI activity.

Anderson's active learning is named to reflect the wider definition of active learning in which students actively take control of their own learning and construct their knowledge themselves (Brame, 2016). The activity is based on Mazur's PI and was adapted to take advantage of teachers' ability to display students' fully worked solutions to classes using tablet PCs and Classroom Presenter software. There has been little research into the use of Anderson's active learning after the initial exploratory studies when it was introduced. This may have been because of the prohibitive cost of the hardware preventing wider implementation.

The four key pedagogies underpinning both Mazur's PI and Anderson's active learning are: engagement, feedback, peer learning, and learning from worked examples.

Student engagement has been linked to desirable learning outcomes (Carini, Kuh & Klein, 2006). Social interaction contributes to engagement in problem solving activities which in turn contribute to higher achievement (Wang, 2017). It is also noted that quieter students can choose to hide their level of engagement (NZ Ministry of Education, 2018).

Feedback has long been acknowledged as making a valuable contribution to learning. Hattie (2012) who conducted a large meta-study of research into influences on learning, confirmed that feedback is one of the most important features of successful teaching and learning.

Peer learning has been shown to enhance understanding (Smith et al., 2009) and for example, to lead to more expert-like viewpoints for physics students (Zhang, Ding, & Mazur, 2017). The student doing the explaining can benefit from restating the explanation in their own words, particularly when explaining a correct solution (Rittle-Johnson, Loehr, & Durkin, 2017) and the student listening may be able to use this explanation to help build their own understanding. However, there is potential for shared misunderstanding if neither student has sufficient knowledge (Sharples et al., 2016).

Worked examples can help students in the early stages of learning new skills by lowering the cognitive load (Tuovinen & Sweller, 1999), particularly when the worked examples are embedded into similar practice exercises (Atkinson, Derry, Renki, & Wortham, 2000).

In this study, we consider these pedagogies when investigating the advantages and disadvantages of using the technology over a period of ten years.

MATERIALS AND METHODS

SETTING

The setting is a first year discrete mathematics course on a computing degree, in which interactive classroom activities using computer technology have been used since 2008 (summarized in Table 1). The classes are taught in alternate semesters by the first author of this paper and another teacher (see Acknowledgements) who was involved with this research until recently.

Prior to introducing the technology, we analyzed the content of every class session and broke it down into short modules, each focusing on a concept. For each concept a problem or a group of problems was prepared on PowerPoint™ slides following guidelines developed by Anderson, Anderson, & McDowell (2005) including leaving enough room for students to write and making diagrams large enough to draw on. We designed our problems to be easy rather than hard, and to aim for success and encouragement for most students.

Table 1. Summary of hardware and software used

Years	2008-2013	2014-2017	2018-
Hardware	Tablet PCs, HP Compaq tc4400	Desktop computers with 20" touch screens	Tablets with stylus
Software	Classroom Presenter	Dyknow Vision	Dyknow Vision*
Students worked:	in pairs	individually	in pairs

* From November 2018, the Dyknow Vision part of Dyknow is no longer supported. Alternatives to this software are being investigated.

DATA COLLECTION AND ANALYSIS

At the end of each semester, students are awarded a final percentage course mark comprising 50% exam and 50% for in-course tests. This is converted to a grade: A (100 – 80%), B (79 – 65%), C (64 – 50%), D (49 – 40%), E (39 – 0%). Any students who have their enrolment withdrawn during the course are given a WD (withdrawn) grade. Students who do not officially withdraw from the class, but do not complete all assessments are given an 'INC' (incomplete grade). There are usually between 20 and 40 students in each class.

We compared grade distributions before (2001 – 2007) and after (2008 – 2015) the introduction of the technology. A Chi-square test for homogeneity of proportions was conducted to test the null hypothesis that the distribution of all grades did not change after the introduction of the technology. Various other subset combinations of grade distributions were also compared and independent sample t-tests were used to compare the pass rate (grade A, B or C) and also the proportion of either A or B grades before and after the introduction of the technology.

The following survey data were collected and analyzed:

- Near the end of each course from 2008 to 2013, students completed an anonymous "Student experience: End of course survey" about their experiences with the technology and its effects on their learning (see Appendix A for a typical questionnaire).
- In 2008, an observer was in all class sessions and "Observer comments" were recorded.
- From 2008 to 2015, "Teacher reflections" were recorded.

In 2008, 2014 and 2015, a selection of 13 problems were chosen and they were categorized as table, text, open or multi-choice (see Appendix B for a typical problem). Students completed an anonymous "Student experience: Problem survey" about the usefulness of these problems for their learning including a problem rating from 1 (low usefulness) to 5 (high usefulness) (Robson & Kennedy, 2013; Robson & Kennedy, 2014) (see Appendix C for a typical problem questionnaire).

RESULTS

BEFORE AND AFTER GRADE DISTRIBUTION COMPARISONS

After introducing the technology, the distribution of all grades did not significantly change $\chi2$ (df = 6, n = 1056) = 2.869 (3 d.p.), P-value = 0.252 (3 d.p.) (See Table 2). Also, the pass rate (i.e. proportion of students with an A, B or C grade) did not change significantly (P-value = 0.15, df = 393). However, the percentage of students who gained either an A or a B grade increased significantly from 25% to 32% (P-value 0.005, df = 393).

Table 2. Percentage of students with each grade before and after introducing technology

	A	B	C	D	E	INC	WD
Before technology, 2001-2007 ($n = 394$)	11%	14%	33%	9%	15%	16%	3%
After technology, 2008-2015 ($n = 662$)	15%	17%	29%	8%	13%	15%	3%

Values rounded to the nearest percentage.

STUDENT EXPERIENCE: END OF COURSE

Engagement with learning

Students were overwhelmingly positive: 97% enjoyed using the technology ($n = 351$), 88% reported that it helped them learn ($n = 387$), 98% found it easy to use ($n = 382$). Students explained how the technology helped them engage with the learning:

> "Made maths a lot more enjoyable and fun. B grade average in a subject I usually find quite difficult."

> "Easier to learn because it's interactive constantly submitting slides so you don't get bored or slack off."

> "They are brilliant wouldn't have passed without them."

> "Made friends through the process."

A disadvantage reported by students is that they sometimes got distracted by drawing doodles or using the internet.

Feedback

Students recognized that an important benefit of using the technology was feedback. When asked to rate the usefulness of feedback, 78% chose "very helpful" or "helpful", 13% chose "OK" and 9% chose "unhelpful" or "very unhelpful" ($n = 339$). Of the students who also added a comment describing how feedback helped them learn ($n = 118$), 89% were positive:

> "I love to see what we all answered and then we discussed and explained the answer. This was helpful as it allowed me to see where I was going right and where I was going wrong."

> "It was good to see other students' methods of solving questions."

> "I was able to assess how much I know as compared to the others which boosted up my confidence, because I thought everybody else was better than me."

> "Can submit an answer without fear of getting it wrong because it is anonymous."

A few student comments (3%) described difficulty keeping up with seeing so many answers. Some students appreciated the anonymous nature of submissions, while other students were observed to be keen to own their submissions when they were being discussed, and a number of students wrote an identifying symbol on their submissions, a result also reported by Anderson et al. (2006).

Peer learning

Students made general comments about peer learning ($n = 155$). Of these, 75% were positive comments and included:

 "If I couldn't remember what to do it was helpful to have someone else share."

"It can force you to explain and reinforce your learning."

"Used to working alone but sharing writing can encourage developing answers together."

Other students (13%) had difficulties with sharing.

"It's all very well working with someone else, but I had a tendency to switch off when my partner was writing."

"Prefer working with someone who is at same level as me. Hard to work with people at lower level."

Revision problem and extra problems

Initially, lessons started with teacher and students retrieving tablet PCs from a trolley, connecting to the local network, and opening software. Some students completed this faster than others and then had nothing to do. This issue was addressed by introducing a revision problem at the start of each lesson so that all students could start a learning activity as soon as they had set up the technology. Those who arrived earlier had more time to do the revision problem and those who arrived later or who took longer to set up could learn from seeing the problem and other students' solutions. This revision problem was helpful for 93% of students and their comments explained its contribution to their learning process ($n = 372$):

"Made me recall what we had done in the previous class."

"Woke brain up at start of class far better than beginning with a passive activity such as lecture/presentation."

When using tablet PCs we provided extra problems for faster students by using an overhead projector (OHP). A few students said these were helpful and others struggled with old technology.

"These questions were helpful because they apply what we have already learned to alternate situations."

"Can't be bothered using old technology. I wished that stuff on OHP was on the tablet."

This issue was solved with the change to Dyknow (see Table 1) as this software makes it easy to deliver extra problems.

TEACHER AND OBSERVER REFLECTIONS

Engagement with learning

The teachers were excited that using the technology appeared to improve student engagement and because of this, the classes were also more enjoyable for the teacher. They described stories of students' enjoyment as:

"Music to mathematics teachers' ears".

"A pleasure to see students enjoying maths."

Teachers noticed other benefits:

"Students came early to class. There was a lot more involvement. They did a lot more themselves in class."

"They appeared to be more engaged with the content."

The observer also noted that student engagement was enhanced:

> "An excellent lesson. Lots of learning. Lots of interaction."

> "With tablets …a bigger variety of activities for students to come to terms with the concepts."

Feedback

Teachers found it quick and easy to comment on student errors and alternative solutions. They could see that students benefitted from seeing their own annotated solutions and also the annotated solutions of other students:

> "Students spend more time looking at other students work and looking for errors and other ways of doing."

> "Students appeared more confident knowing that other students made mistakes too."

The observer noted:

> "Students appear to learn from looking at the displayed solution and comparing with their own attempt."

> "Although the displayed solutions are anonymous, some students are quick to own a solution and appear to appreciate their work being part of the class."

Peer learning

For the first six years when students shared tablet PCs, peer learning was a highlight as it set the tone of the class. The teachers loved moving round the class listening to the buzz of conversation:

> "…and it was all about the current problem and about mathematics!"

> "It was great to see every pair talking about the problem, working and helping each other."

> "It was great to see a good student learn by explaining to a weaker student."

> "Sometimes one pair helped another. Sometimes pairs competed. The front pair would send theirs in and then turn around to see if they'd beaten the other pair."

> "The activity gave me the opportunity to promote class dynamics by pairing national with international students, stronger with weaker students."

The observer noticed the noise level in the class:

> "…the teacher was walking around the class and every pair was talking about the problem on their tablet. It was louder than a normal class. If a normal class has this noise level in maths I would expect much of the talking to be off topic."

Between 2014 and 2017 when students worked individually (see Table 1), teachers noted:

> "Classes just don't have the same buzz. Sharing is really important."

In 2018, peer learning became a highlight again with the change of hardware to Windows tablets with styli. This gave us the best of both of the previous systems, peer learning and enhanced feedback, without the disadvantages of the previous systems.

STUDENT EXPERIENCE: PROBLEM-TYPE SURVEY

In this survey, there were 583 student responses from ten different classes in 2008, 2014, and 2015. The responses comprised 13 different problems and four different problem types (table, text, open, and multi-choice).

The majority of students found all problem types useful for their learning (Figure 1). There was a slight preference for table, text and open problems (median problem rating 4) over multi-choice problems (median problem rating 3).

We found that the majority of students still found most problems useful for learning even if they also said they were hard or easy. Of the 583 responses, 17% reported problems as "hard" or "too hard", but of these 71% said that the problem was useful for their learning. Similarly, 22% of responses reported problems as "easy" or "too easy", but of these 78% said the problem was useful for learning.

As expected, students rated problems higher (median problem rating 4) when they found them useful for learning than when they reported them not useful for learning (median problem rating 2).
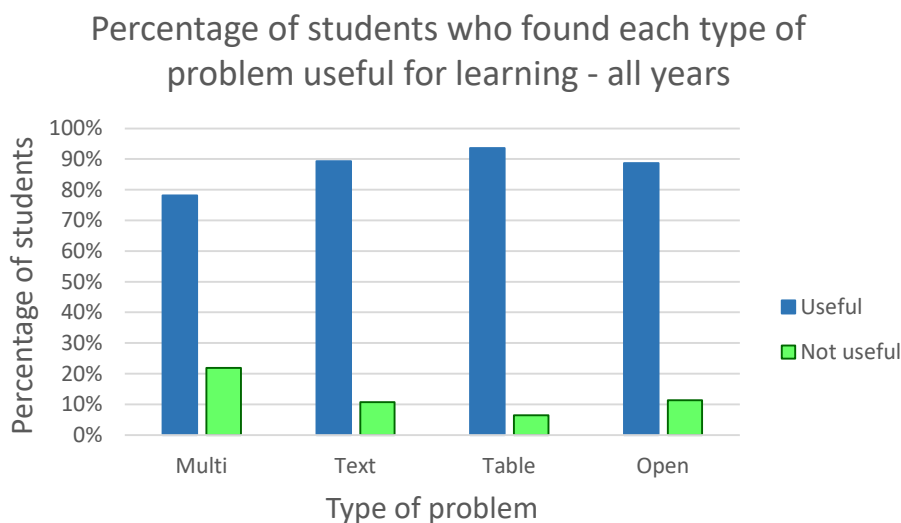

Figure 1. Problem type differentiated by student perception of usefulness

Teachers found it challenging to write good multi-choice ConcepTests that focused on concepts but easy to write open questions and problems in which the solutions submitted by students displayed their understanding of concepts, alternative solutions and misconceptions. The fully worked solutions submitted by students made it easy for teachers to focus on conceptual understanding during the explanation of answers. They also noted that questions and problems that led to students submitting an answer only, did not lead to a class discussion based on higher-level thinking unless students were also asked to justify their answer.

DISCUSSION

ADVANTAGES OF THE TECHNOLOGY

The significant increase in the proportion of A or B grades indicates that using the technology may enhance academic performance for some students. However, there are limitations to drawing conclusions from course grades. Although the course grades for the seven years prior to the intervention provide a control group component, course grades over fifteen years are influenced by many factors with the intervention being only one factor. There is potential for future research to conduct controlled experiments in which learning gains associated with the active learning activity are measured.

Both students and teachers saw other learning benefits of the technology. The results indicate that many students enjoyed the classes and recognized that this helped them learn. This evidence supports the finding of Carini et al. (2006) and Wang (2017) that engagement is associated with learning.

Students described how they learnt from feedback about correct solutions, from seeing others mistakes and from seeing other ways of solving problems. Teachers noticed that student confidence was boosted by being able to contribute to lessons anonymously and by seeing how their work compared with others. The feedback provided by the interactive learning activity is consistent with Hattie's recommendations (Hattie, 2012), that it should answer three questions:

- *What are my goals?* In our setting, the goals for a problem are shown by a correct and clearly worked solution that is selected by the teacher, displayed, and annotated. Furthermore from 2014, Dyknow allowed the teacher to send this annotated worked solution to all students immediately after completing a problem, thus embedding worked examples with practice problems as recommended by Atkinson et al. (2000).
- *How am I going?* Students can easily compare their solution with the displayed solution as all students use the layout provided by the problem.
- *Where to next?* The teacher selects and displays other student solutions and indicates tips, common errors, and alternative solutions. Students can use these to see how they can improve their solutions. Alternative solutions can easily be included in a lesson thus providing opportunities for students to develop mathematical understanding and flexibility as described by Star and Seifert (2006).

Peer learning was a strong component when sharing tablet PCs (2008 – 2013) and students learnt by explaining solutions as well as receiving guidance from others, a finding consistent with that of Rittle-Johnson et al. (2017). A few students found working with others difficult but our local computing industry tells us that they want to employ graduates who can work in teams. We took advantage of this opportunity to help students learn team skills by discussing techniques. We also organized different pairing of students to give them multiple opportunities to practice working with others.

From 2014 to 2017, the change to touch screen computers substantially reduced technical problems as the computers are connected to the main student network and are supported by technicians. At the same time, the change of software from Classroom Presenter to Dyknow provided advantages. Dyknow allowed teachers to send extra problems for faster students and to send copies of important worked solutions to students. In addition, Dyknow allowed students to easily export their work in a standard format.

The technology enabled teachers to present a variety of problem types to students. Mazur (1997) wrote "ConcepTests" consisting of multi-choice problems about physics concepts that students used hand held clickers to answer. However, we found that it was not easy to write good multi-choice problems about mathematical concepts, but that we were able to easily write table, text and open problems designed for answering with digital ink.

DISADVANTAGES OF THE TECHNOLOGY

Students' comments about disadvantages when using tablet PCs were mainly about technical problems and the ability to save their work and notes. These issues were resolved when we changed to touch screen computers with Dyknow, but other disadvantages arose. Most of the peer learning that was integral to the activity was lost when we changed to touch screen computers as students worked at individual computers and most preferred to work on their own in this environment.

Another disadvantage of our 2014 touch screens was that the quality of the digital ink was low. However, we had to accept this as touch screens were a cost effective solution when the tablet PCs needed replacing and tablets suitable for running Dyknow were still too expensive.

The teachers observed that in some classes there was one student who could not bring themselves to use the technology and we usually allowed such students to work in the way they were comfortable. We were surprised as all students were studying computing, but it appears that for some students using technology interfered with their learning of this course.

A few students struggled to process seeing so many solutions, however learning to filter information in a useful way is an important part of modern learning and we learnt to carefully explain what to look for in each displayed submission and to give students enough time to do this.

CONCLUSIONS

Over a ten year period, students, teachers and observers were consistently positive about their experiences with the technology and reported learning benefits from the pedagogies that underpin it. Students reported that engagement, peer learning, feedback, and worked examples contributed to their learning and this was also observed by teachers and observers. Furthermore, the majority of students found all problem types useful for learning even those rated "too hard" or "too easy". An advantage for teachers is that they found it much easier to write suitable questions that elicited higher level thinking than to write multi-choice ConcepTests.

There was a significant increase in higher (A & B) grades, although pass rates did not increase significantly after introducing the technology and there are limitations to drawing conclusions from course grades over a period of many years.

From 2018 we are using new tablets and are finding that this modern technology enables all the advantages of using tablet PCs (peer learning, feedback, and engagement) as well as the advantages of Dyknow software (sharing worked examples and delivering extra problems). The modern technology also overcomes all the disadvantages of using tablet PCs (affordability, availability, technical problems) and the disadvantages of using our touch screens (poor digital ink and very little peer learning). We have been able to apply our learning from the last ten years of experience and research to implementing interactive classroom activities that help students learn, while also motivating both students and teachers. In addition to the guidelines established by Anderson et al. (2005), Anderson et al. (2006), and Anderson et al. (2007) we make the following recommendations:

- Arrange for students to work in pairs.
- Write problems that elicit students' understanding of concepts in their submitted solutions.
- Write problems that elicit alternative solution strategies and common misconceptions.
- When students solutions are displayed, give feedback that focuses on concepts, alternative solution strategies and common misconceptions.

Currently, affordable tablets with styli allowing good quality digital ink are readily available. Thus, there is potential for the active learning described in this paper to be widely implemented and researched. Future research should focus on controlled experiments, in which learning benefits attributable to the activity can be measured, in large tertiary classrooms.

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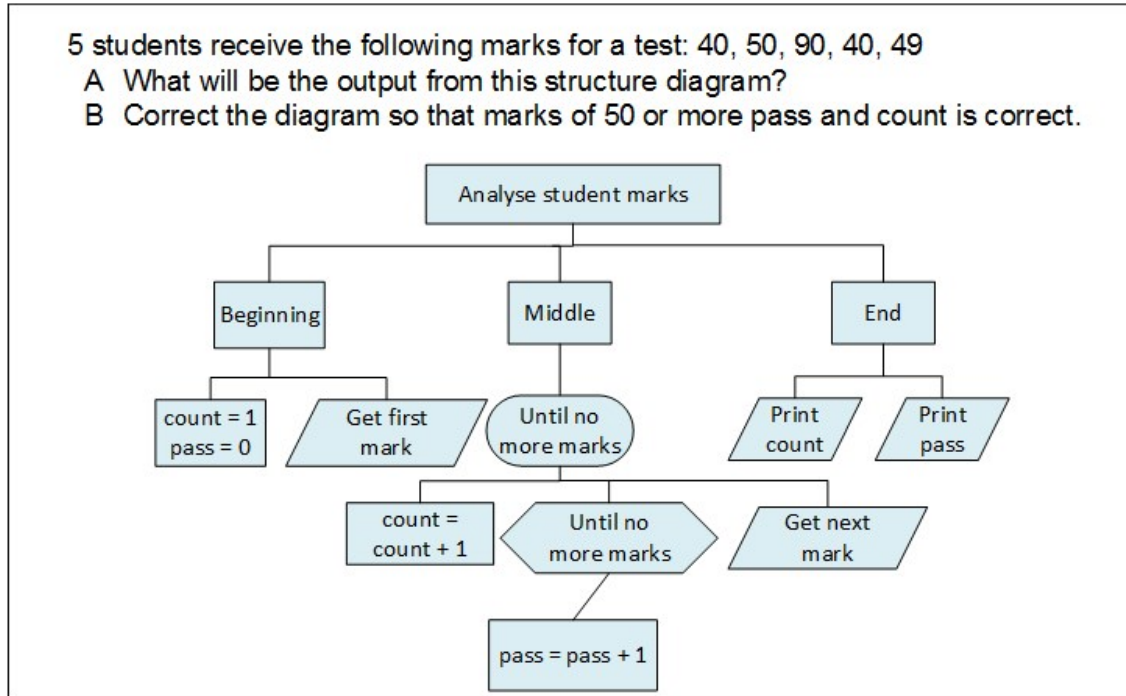
APPENDICES

APPENDIX A: STUDENT EXPERIENCE: END OF COURSE SURVEY

1. Easy to use? Agree/Disagree

2. Enjoyable? Agree/Disagree

3. Helped learning? Agree/Disagree

4. What were the advantages of using the technology for learning?

5. What were the disadvantages of using the technology for learning?

6. Did the revision question at the beginning of each lesson help you learn? How?

7. The teacher selected, displayed and commented on students' submissions or answers.

   a. How useful was this for your learning?

   ☐ Very unhelpful　　☐ Unhelpful　☐ OK ☐ Helpful　　☐ Very helpful

   b. Please comment.

8. Please write any other comments about how using the technology affected your learning.

APPENDIX B: EXAMPLE OF A PROBLEM

5 students receive the following marks for a test: 40, 50, 90, 40, 49
  A What will be the output from this structure diagram?
  B Correct the diagram so that marks of 50 or more pass and count is correct.

Analyse student marks

Beginning   Middle   End

count = 1
pass = 0

Get first
mark

Until no
more marks

Print
count

Print
pass

count =
count + 1

Until no
more marks

Get next
mark

pass = pass + 1

APPENDIX C: STUDENT EXPERIENCE: PROBLEM TYPE SURVEY

1. Was this problem useful for your learning? Yes/No

2. Was this problem:

   ☐ Too hard   ☐ Hard   ☐ About right   ☐ Easy   ☐ Too easy

3. Did you know to start this problem? Yes/No

4. Did you learn when viewing other students' solutions? Yes/No

5. Did this problem help you feel confident about doing this type of problem? Yes/No

6. Rate this problem on a scale of 1 (low) to 5 (high). You can use a whole number or a decimal.

7. Write any comments you have about this problem.

BIOGRAPHIES

Daphne Robson is Program Leader for Mathematics and Statistics at Ara Institute of Canterbury in Christchurch, New Zealand. Her research interests and publications are in the areas of applying known pedagogy in innovative ways with the use of technology, using technology in effective teaching, and designing and developing software with a pedagogical focus.

Dr Britta Basse is a lecturer in Mathematics and Statistics at Ara Institute of Canterbury in Christchurch, New Zealand. Her research background is in applications of mathematics to ecological and agricultural sciences.