Digital Mathematics 2020 Innovation Trial Evaluation and Closure Report

NCEA Online Programme

NZQA
NEW ZEALAND QUALIFICATIONS AUTHORITY
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Digital Mathematics 2020 Innovation Trial
Evaluation and Closure Report

NZQA would like to acknowledge the participating schools, teachers and students for their support of this innovation trial and contribution to its success.

While we have done our best to accurately represent the findings of this innovation trial and the views expressed by participants, NZQA accepts responsibility for any omissions or inaccuracies in this report.

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1 Innovation Trials and their place in the NCEA Online Programme

The work of innovation trials is informed by NZQA's strategic thinking as expressed in the Digital Assessment Vision[1], Te Kōkiritanga strategy and its overarching vision: 'Ākonga Māori qualify for the future world'.

In line with that vision, the NCEA Online Programme prioritises work that aims to optimise the examination experience for Māori and Pacific learners.

All data collected in innovation trials must be able to be disaggregated to enable NZQA to identify and learn about the needs or preferences of Māori, Pacific and all learners. To this end, innovation trials will collect data that enables identification of student ethnicity. Inclusion and publication of ethnicity data will be suppressed for privacy reasons where student numbers are below a level where this is appropriate.

2 Trial overview – Digital Mathematics 2020 Innovation Trial

In 2019, NZQA trialled digital mathematics activities with New Zealand schools. The Project Steering Committee accepted a recommendation to continue investigation into digital mathematics with a second trial in 2020. This would allow NZQA to gain further experience in digital mathematics assessment and address some of the issues raised in the 2019 trial.

NZQA used the 2020 trial to test and evaluate using digital activities to assess students against the externally assessed AS91262. This aligned with NZQA's goal for digital assessment and dovetails with changes that are expected to occur as a result of the current Review of Achievement Standards (RAS).

The decision to use the Level 2 achievement standard AS91262 was driven by Review of Achievement Standards (RAS) timelines and the challenge of modifying and redefining calculus assessment activities. This is because we needed to use a level two or three standard as level one changes from the RAS will be the first to come onstream.

[1] https://www.nzqa.govt.nz/about-us/future-state/digital-assessment-vision/

The focus of the Digital Mathematics 2020 Innovation Trial was:

- building on the lessons learned and recommendations from the Mathematics 2019 Innovation Trial. Lessons learned included improving the literacy of the questions and ensuring the literacy level was pitched correctly for the standard and only including schools and students who have used Desmos (the digital mathematics tool selected for the 2019 digital mathematics trial) for teaching and learning in the trial
  See Appendix Eight for a full list of lessons learned
- evaluating and determining the most suitable digital mathematics tool for the trial
- using the selected digital mathematics tool to develop a prototype digital assessment activity that would provide an opportunity to assess students for AS91262 – Apply calculus methods in solving problems
- devising and trialling activities which modify and redefine traditional questions and problems for the externally assessed standard AS91262.

Following the initiation of the trial, tools suitable for building digital mathematics were evaluated. Mathematics teachers were surveyed and asked to provide details of, and feedback on digital tools they use for teaching and learning. Desmos was selected as the most used and highly rated tool.

The digital mathematics development group which consisted of four teachers and the National Kaiarahi for the Mathematics and Statistics Networks of Expertise, attended a workshop with the NZQA trial lead and business analyst at NZQA in March 2020. Desmos joined the workshop remotely. The workshop's purpose was to initiate the development of digital assessments for trialling with students. Following the workshop the teachers collaborated remotely to develop three digital mathematics activities.

Integration with the NCEA Online platform (Assessment Master) was not considered and was out of scope for the trial.

Schools were invited to trial the digital activities. In total, 14 schools trialled the activities during term 3 2020.

Teachers and students who had completed the trial provided feedback via an online survey. Focus interviews with the development group and a selection of teachers who participated in the trial were also conducted to provide greater insight into the trial outcome.

3 Trial objectives and design

The objectives of the Digital Mathematics 2020 Innovation Trial were:

1. To develop prototype digital assessment items for the assessment of AS91262 – Apply calculus methods in solving problems.

2. To incorporate digital mathematics tool(s) into digital mathematics assessment for AS91262.

3. To understand how the use of digital mathematics tools enable the modification and redefinition of assessment items.

4. To utilise the opportunities within a digital environment to increase the engagement and resilience of NCEA students when taking part in external assessment.

In the context of the trial, resilience means students continue with the activity rather than giving up when faced with challenges.

5. To use lessons learnt from the first digital mathematics trial (2019) to improve the design of activities.

6. To investigate whether providing digital assessments of mathematics enables equity of access for Māori and Pasifika.

4 Summary of the trial of Digital Mathematics 2020 Innovation Trial

4.1 Trial phases

The trial milestones are described in the table below. Several milestones were delayed due to the COVID-19 level 4 lockdown in term1.

Milestone	Original date for completion	Date completed
Workshop with development group	March 2020	March 2020
Identification of, and engagement with participating schools	February 2020	n/a
Teacher survey about commonly used digital teaching tools for mathematics	March 2020	March 2020
Request schools register interest in trial	Not in original proposal	End of term 2
Development group collaborate remotely to build activities and develop marking schedules.	May 2020	August 2020
Webinar	Not in original proposal	July 2020
Critique by members of examination panel and subsequent revision of activities and marking schedules	May 2020	August 2020
Showcases	Not in original proposal	September – December 2020
Trial the activities with teachers and students	July 2020	October 2020
Evaluate trial	August 2020	November 2020

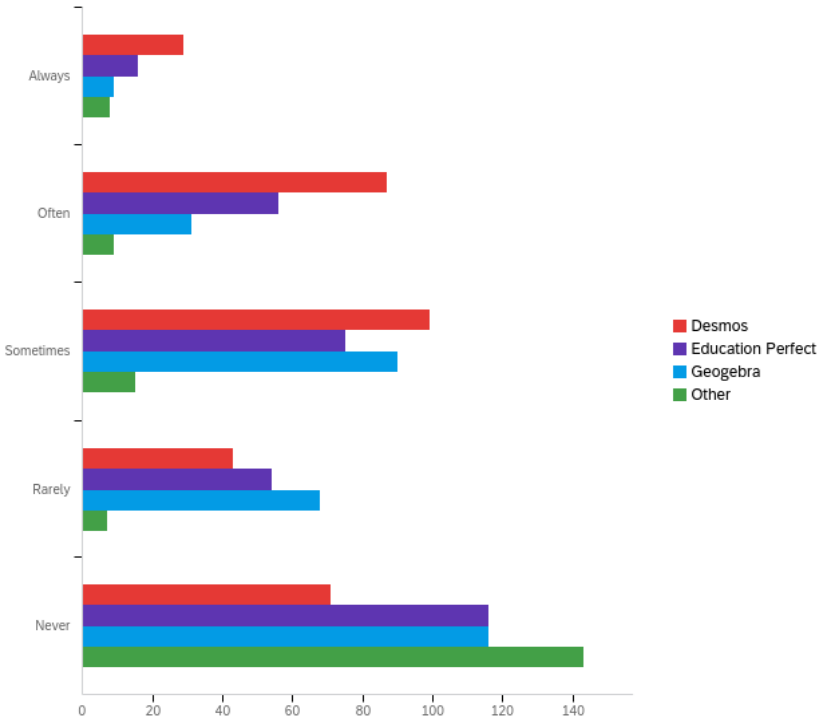
4.2 Evaluation of digital tools

A range of digital mathematics tools were evaluated to determine the most suitable tool for the trial. The evaluation included the following activities:

- Surveying Heads of Departments (HODs) and teachers in charge (TIC) of Mathematics in New Zealand Secondary Schools about the use of digital tools used in the teaching and learning of level 2 calculus.
- The survey questions were designed, and the survey created, by NZQA and then distributed to HODs and TIC via New Zealand Association of Mathematics Teachers (NZAMT).
  See Appendix One for a list of survey questions.
- Evaluation of several digital mathematics tools against a set of evaluation criteria.

The survey requesting feedback about the use digital environments in the teaching and learning of mathematics was a voluntary survey advertised via the email lists of the National Kaiarahi for the Mathematics and Statistics Networks of Expertise. The survey was also advertised on three Facebook pages. New Zealand Mathematics Teacher, New Zealand Statistics Teachers and New Zealand Calculus Teachers. The survey also asked for information about the use of digital environments in the teaching and learning of statistics as NZQA was trialling digital statistics in parallel with digital mathematics.

There were 401 responses to the digital mathematics survey.168 of the respondents were curriculum leaders and 238 were classroom teachers.



Number of responses

The responses to question 5 (Do you use any of the following digital mathematics applications for teaching and learning at your school for Level 2 Achievement Standard 91262 Apply calculus methods in solving problems?) demonstrated a preference for Desmos and then GeoGebra,

followed by Education Perfect. There was a low number of preferences for other environments such as Wolfram.

Survey respondents were also asked if they had any comments or feedback on the digital mathematics applications they had used for teaching and learning. Responses were mixed with some in favour and some against the use of digital assessment for calculus. For example:

- *The students enjoy using them*
- *Without manual solution to algebra, and the understanding needed to sketch graphs of functions, students are not helping themselves. I use IT resources sparingly until students are "manually competent"*
- *It should match what is required at university because we know that Auckland Uni does not allow Graphics Calculators for Engineering and Biomed courses.*
- *It is too difficult and time consuming for students to show their working*
- *Hope we can have digital mathematics test rather than on paper*
- *Great tool. Haven't had a need to use or investigate other equivalent software. We have this installed on all student devices.*
- *Why not allow Desmos in externals? It provides an extra rich dimension to investigation.*
- *We primarily use DESMOS as this is a very user-friendly application and it aids students understanding.*
- *GeoGebra is great for introducing differentiation and can be used for a nice approximation to first principles.*
- *I find that a subject like calculus (and algebra) are best done with pen & paper. Students prefer it.*

4.3 Supplier for the Mathematics Trial

Desmos was used to create digital mathematics activities for the 2019 Maths Innovation Trial.

Desmos was again selected for the 2020 digital mathematics trial because it was identified as the most widely used digital tool via the teacher survey.

Desmos worked with the development group to finalise and publish the activities. Desmos has quality assurance standards that must be met before activities that they have been involved in developing can be published on their site. The knowledge and skills of the Desmos team meant that to the digital platform could be leveraged to reimagine the activities, a capability not available in the development group.

4.4 School participation

The planning for this project took place before the COVID-19 pandemic. The COVID-19 pandemic restrictions had a significant impact on the ability of participating schools to engage with the trials and prepare students for the activities.

The Innovation Trial Digital Mathematics Proposal stated approximately ten schools would be selected to trial the activities. Schools spread across deciles, ethnicities, locations and types of schools would be selected, to ensure participating schools were widely representative of New Zealand students. However, when the COVID-19 Pandemic and level four lockdown in March provided an opportunity to support remote teaching and online learning, a decision was made to open the trial invitation to all New Zealand secondary schools.

NZQA used the following channels to invite teachers to participate in the trial:

- Email lists from national and regional Kaiarahi for the Mathematics and Statistics Networks of Expertise.
- Posts on the NZ Mathematics and NZ Calculus Teachers Facebook pages.
- Posts on the NZAMT website and those of the regional associations.

This resulted in 48 registrations from teachers from 45 schools wishing to participate in the trials.

Schools were asked to complete the activities and provide feedback via separate student and teacher surveys by the end of term 3. Students were provided with activities that could be used to familarise themselves with Desmos and the kinds of questions that they would be given. Teachers were provided with support material including information on how to access Teacher Desmos. Teachers were advised that students could access and complete the activities at any time and activities did not all need to be done at once. Feedback was received via the student and teacher surveys from 14 schools, with 191 students completing surveys about the trial activities. Of these 17 (9%) identified their ethnicity with Māori and 9 (5%) with Pacific Peoples. 54 (28%) students were Year 11, 133 (70%) year 12 and 3 (2%) were Year 13 or above. See Appendix Six for a list of participating schools.

4.5 Marking

Teachers were provided with an assessment schedule and students were given access to the activities via Teacher Desmos and their response were saved within that platform for marking. Teachers then accessed these for marking. We did not collect students' results as the purpose of the trial was not to evaluate how students achieved using the digital activities but whether they could achieve at all levels of the standard. Teachers were asked via the survey if they believed that the activities provided an opportunity to award all levels of achievement.

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4.6 Sector Engagement

Teachers who had expressed an interest in the activities and trials were invited to attend a webinar which showcased the activities and offered teachers support with preparing students for trialling. 60 teachers attended this webinar, which was recorded and made available online for teachers who could not attend the live webinar.

Further webinars and presentations were made available to the sector while the trials were in progress. The purpose of the presentations followed a policy decision to be transparent with the sector and create awareness of the trials. Audiences included:

- Southland Heads of Department
- University of Canterbury mathematics staff

- New Zealand Mathematics Association Education Committee

Invitations to present and provide information about the trial at events post-trial were received for:

- Auckland Mathematics Association Calculus Day
- Victoria University Mathematics day

4.7 Summary of Feedback and Survey Responses

Survey responses were received from 207 students and 10 teachers who had participated in the trial. Sections 4.5.1 to 4.5.5 describe data from these responses.

Survey results showed that most students agreed that the activities were engaging and the animations helped them to understand the context. However, most students reported that they did not believe they could improve achievement with digital activities or that the activities encouraged them to persevere with mathematical problems.

Post-trial interviews with teachers suggested that students would achieve better with digital activities and be more resilient if they had been given significantly more opportunity to engage with Desmos before undertaking the activities.

4.8 Evidence of all levels of achievement

The development group collaborated with Desmos to produce three digital activities. Extracts from the activities are available in Appendix Seven. The process used to develop the activities was a continuous cycle of creation, review and improvement. Subject experts, teachers, the National Assessment leader and a representative from the New Zealand Association of Mathematics Teachers provided feedback designed to ensure that the activities offered opportunities for all levels of achievement.

Each activity was similar in design to one question of a traditional paper external examination. Students could be awarded a similar number of u (Achieved), r (Merit) and t (Excellence) marks for answering sections of the activity. The activity and the assessment schedule were reviewed by a materials critiquer from the NZQA examinations panel for AS91262. This feedback was used to further revise the activities and schedule to meet the national standard. Note: Quality procedures were not as robust as for external examination papers, and participating schools were made aware of this.

Teacher responses

All teachers who responded to the survey agreed that each of the three activities offered students the opportunity to demonstrate all three levels of achievement.

4.9 Equitable access on BYO device

The shift from inviting selected schools to participate in the trial, to extending the invitation to all schools meant NZQA could not ensure that participating schools would provide diverse demographic data. One consequence of this was that only a very small number of students of Māori and Pacific ethnicity participated in the trial. An evaluation question was included in the proposal to measure whether the activities provided equitable access to the activities for Māori and Pacific students. It was not possible to draw any meaningful conclusions about whether the digital format of the activities had provided equitable access for Māori and Pacific students due to the lack of Māori and Pacific students that participated in the trial.

Student survey responses

Most students used laptops to access the devices. Students from one school used desktops.

What sort of device did you use for these activities

Q22 - What sort of device did you use for these activities? Select all that apply...	Count
Chromebook	16%
Desktop	20%
iPad	1%
Laptop	64%

Most students responded “other” to the type of browser: teachers’ responses indicated that this referred to Chrome.

Q23 - What browser or browsers did you use for the activities?	Count
Firefox	2
Microsoft Edge	6
Other	165
Safari	10

The vast majority of students engaged with the activities at school.

Where did you do the activities

Q25 - Where did you do the activities? Select all that apply - you may have done...	Count
At home	5%
At school	98%
Other	1%

Five students reported network problems.

A common thread from students was the difficulty with entering mathematical symbols and equations using the keyboard.

Teacher survey responses.

Teacher comments aligned with student concerns about mathematical symbols and equations. These comments also noted that this was less of a concern if students had had sufficient exposure to the platform beforehand.

- *Students needed to use Desmos beforehand. Not having experience with Desmos disadvantaged some students.*
- *The students were not familiar enough with Desmos to be able to quickly type in the gradient function (i.e. powers and fractions) and found this easier and quicker to do on paper*

Teachers' comments included:

- *We need to be using Desmos with our students and having them use Desmos so they can navigate the site more readily.*
- *Make sure that they (students) know how to use the keyboard to type formula.*
- *Students need lots of practice and found the first one very difficult even though we had done something similar.*
- *Get students very used to how DESMOS works and use it throughout the year.*

4.10 Modification and redefinition of assessment questions

The objective of the trial was to explore tasks that use the benefits of technology while preserving the open-ended richness of paper tasks.

Some of the benefits were straightforward, including ease of marking and use of a medium that students are increasingly accustomed to. This summary of the benefits focuses on aspects of task design that are possible with Desmos' technology and can't be achieved, or are difficult to achieve, with paper. Desmos alerted NZQA to the specific features of digital assessment that support modification and redefinition of assessment questions which are described below.[2] These features were not included in the digital mathematics innovation trial proposal but were used in the trial.

Traditional paper based assessments do not allow for the following aspects of digital assessment as it is not possible to use scaffolding (where the later part of the question does not rely on getting the first part of the question right) or provide instant feedback and an opportunity to re-attempt incorrect responses:

1. We began with an easy and engaging question, making the task accessible to the student.

- Students engaged with the context through an engaging, animated and accessible introduction.
  For example, in "Tiers of Joy," students started by exploring different dimensions of cake as an introduction to the context they would be navigating:
- The interactive nature of this activity meant it wasn't possible on paper.

2. Giving feedback and support for multiple attempts

> Most tasks in life allow us more than one chance to get something right - and it's from our early missteps we gather critical feedback and clues for how to improve our work.

[2] Desmos, communication received by Neil Marshall about reimagining.

In instruction, students receive feedback and can revise. We wanted the same for assessment to:

- give students an opportunity to persevere in problem solving
- feel the satisfaction, closure, and confidence of verifiable success
- ensure that students weren't being marked wrong from simply misunderstanding the question.

In each case, feedback connected to task completion and interpreted the responses versus solely providing a correct/incorrect indication. For example, in "Dock the Shuttle", students had to show their working for an excellence-level calculus task and could check their work with a simulation.

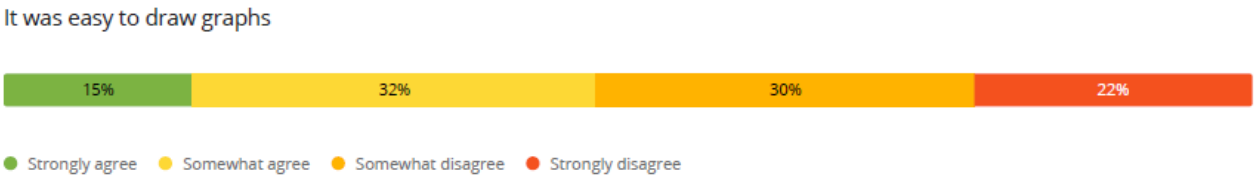
The number of attempts was shown to the student and to the marker. Live feedback was provided during the activities so the student could see correct answers where needed and see where they went wrong.

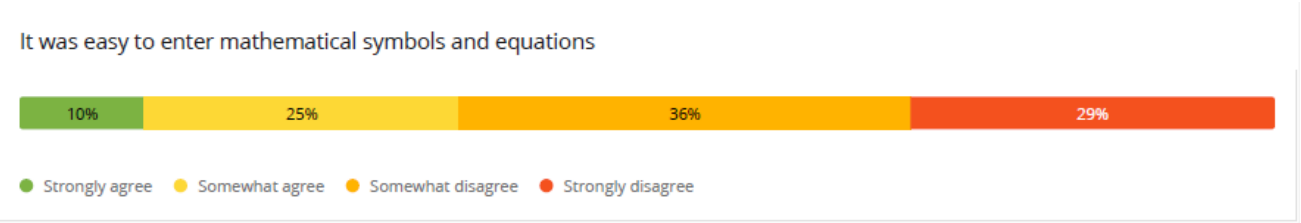
3. Scaffolding and differentiation

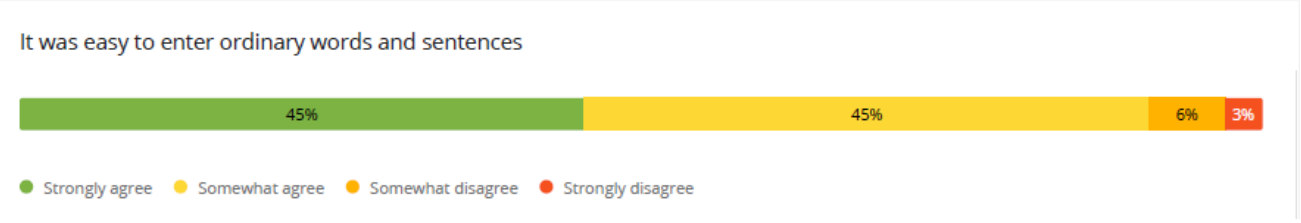
On computers, different students can be shown different information, and that information can adjust based on the student's work. As such, it's possible to ask multi-part questions where success on a later part doesn't *need* to rely on the success on an earlier part. For example, in "Tiers of Joy", students attempted to find a formula, which stretched their algebraic skills. Since this was a calculus assessment, failure to find that formula shouldn't have stopped them from showing they could select and use differentiation. This trial offered them the opportunity to proceed and request the formula.

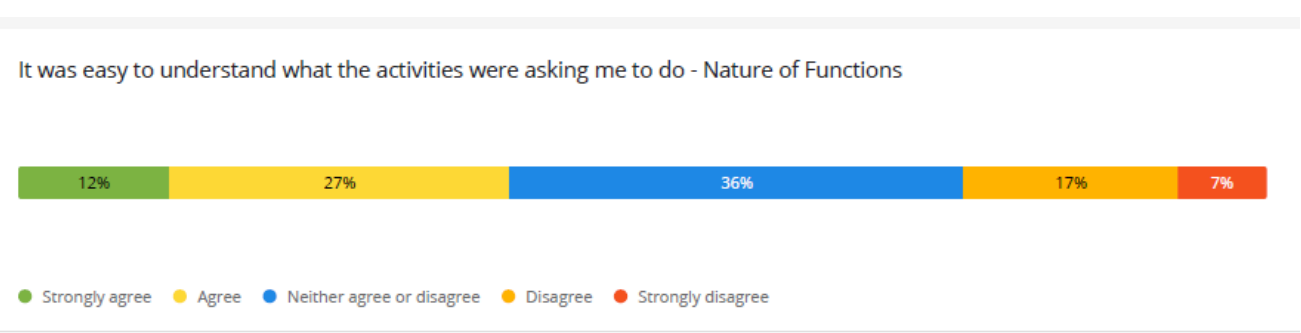
By contrast, on paper, every student sees the same content and as it is static, it can't adjust to a student's needs or work.[3]

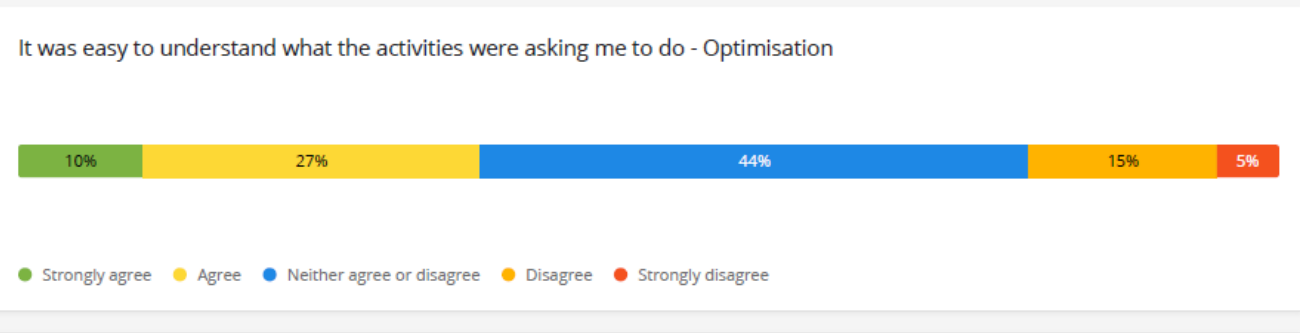
Student survey responses











Teacher survey responses

These were generally favourable when considering if the modification and redefinition of assessment questions had been successful in this trial.

- *Clear diagrams, moving points (e.g. for sketching gradient functions)*
- *I enjoyed the context. I also liked seeing where the students were struggling as it happened, so it was very informative.*

- *It was very good for drawing gradient function and vice versa, also visualizing tangent and equation of tangent.*
- *Able to self assess whether they had SOME answer correct*
- *More practical and visual. Nice to have a lot of the "donkey work" taken out of questions*
- *The matching of function and derived function activity generated some good discussions.*
- *The visual representation of the problem*
- *It really test students' understanding of the concept rather than skills of how to solve a question.*
- *Interactive.*

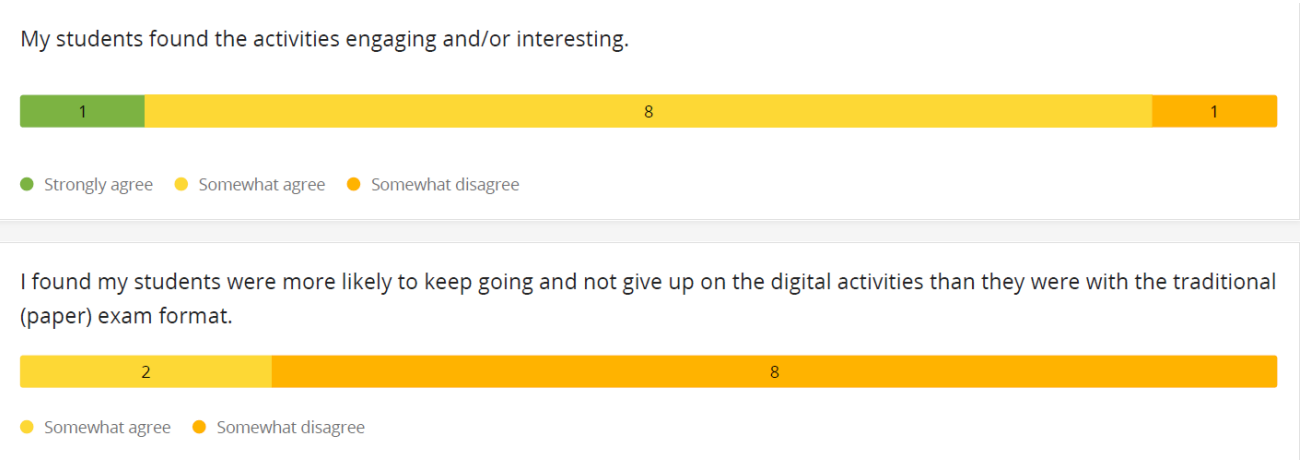
4.11 Encouraging engagement and resilience

Student survey responses

Below are some examples of student feedback:

- *This dock the shuttle was pretty good.*
- *The videos about the space shuttle were helpful.*

Teacher survey responses

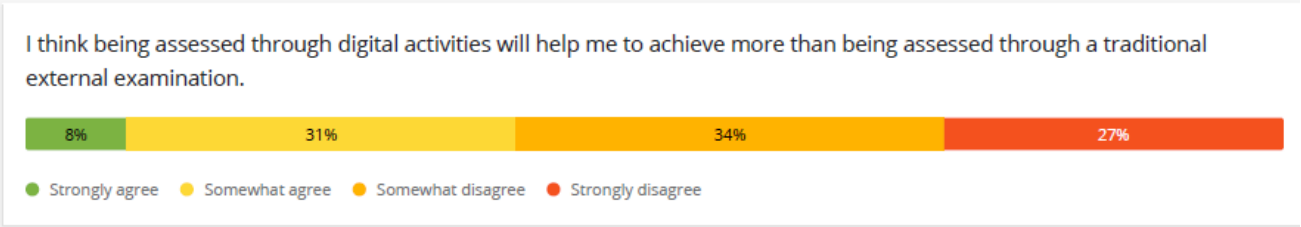


Below are some examples of student feedback:

- *These were very engaging tasks and my students really enjoyed it.*
- *I think it is the way forward*

4.12 Maximising achievement

Student survey responses



9 students commented that they preferred paper assessments

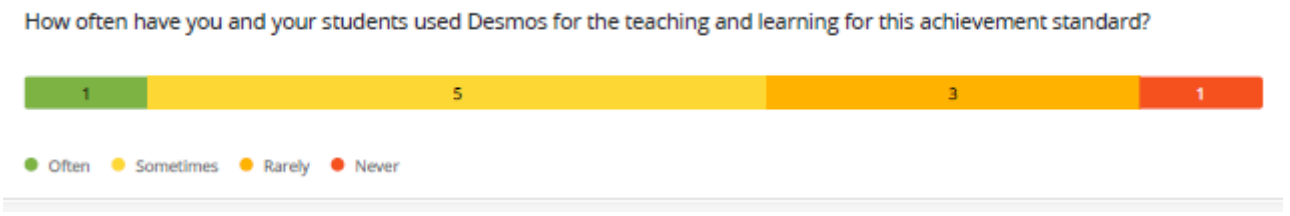
- *Stick with traditional paper please*
- *stick to paper its just better*
- *Much prefer paper assessments*
- *Maths should stay on paper.*
- *Maths should always be pen and paper.*

- *It's really hard to do online and it takes me longer to understand I don't like it :(*
- *It's not very easy to write equations online*
- *It was hard to type out mathematical symbols, its much easier to write on paper*
- *I really do not think that digital exams are at all a good idea.*
- *I don't think math exams should be online, as it takes more time to write down formulas on your laptop than on paper*

However, some comments were in favour.

- *Yes your system isn't flawed and I really enjoyed it. Cheers*
- *it was good.*
- *It is a lot easier to understand the questions*
- *I find this experience interesting and useful and look forward to the future of digitally-held exams.*

Teacher survey responses



- *They all scored less than on paper and whilst they enjoyed the activities, they all preferred paper.*
- *My students said they preferred working on paper and did not want to do their exams digitally*
- *I found them a nice change from traditional learning and to help reinforce some concepts but I don't think they were particularly well-suited to assessment.*

4.13 Teacher Interviews

Focus interviews were designed to elicit further feedback about the trial and were conducted with a selection of teachers. Focus interviews were structured and used the interview questions in the appendices.

School 1

School 1 is a co-educational state school on the east coast of the North Island. It has a roll of between 500 and 1000 students with around 70% students of Māori descent and 20% European.

Teachers generally taught most of the calculus work before looking at the trial support materials, however. The Head of Department thinks it would have been better if students had had more time to reinforce their knowledge before completing the activities.

Half of the class had used Desmos in year 11 as well as year 12, so were quite confident but some were still unsure. One of the biggest issues with using Desmos was that students were either on Chrome Books or laptops, neither of which have a touch screen for drawing the graphs.

There was a definite divide in terms of how students coped with the style of question - those who are working at merit or excellence level could cope with the questions, were motivated to answer them and were keen to get it correct. Those working at achieved level, found the style more confusing and had a tendency to give up. She felt for that group, the task did not give them the same results as completing a written problem.

Students did have access to paper and pencil whilst using Desmos. Many of them preferred to write it on paper before inputting their final answer into Desmos.

School 2

School 2 is a co-educational state school in the Wellington region. It has a role of between 1000 and 1500 students. 70% of students are of European descent and 20% are of Māori descent.

This school has participated in digital assessments for NCEA and students are very comfortable with the existing assessments.

The mathematics department uses Desmos regularly within teaching and learning. Desmos was used extensively with the participating students for remote learning and assessment for internally assessed achievement standards during COVID-19 alert levels 2,3 and 4.

Participants were given training and support in using the Desmos MathType editor and found it easy to use.

The participants were not allowed pencil and paper. The student results were as she would expect from a traditional paper assessment – both in terms of the rank order of the students and the grades they achieved. For example, students who usually achieve excellence, achieved excellence.

4.14 Outcome of the trial

The planning for this project took place before the COVID-19 pandemic. The COVID-19 lockdown and had a significant impact on the ability of participating schools to engage with the trials or prepare students for the activities.

Consequences of this are:

- the volume of data collected at the end of the trialling period was not as diverse as it was expected it would be if NZQA had selected the schools
- an inadequate number of Māori and Pacific students participated which resulted in inadequate data for investigating equitable access. The original plan was to select schools that could provide a cohort of Māori and Pacific students so that we could investigate the outcomes of the trial for these groups

The trial has demonstrated that this achievement standard can be assessed in a digital environment and used for external assessment. It would be possible to package three similar activities in such a way they could be offered as an external assessment under exam conditions. It is likely this style of assessment is unlikely to be successful unless it is integrated within a teaching, learning programme and assessment programme so that learners are immersed in a cohesive digital experience through all three phases.

4.14.1 Answering the trial's evaluation questions

Do the activities provide evidence for the standard at all levels of achievement?

The three digital activities offered students opportunities to demonstrate all levels of achievement.

Do the activities provide equitable access to the activities on BYO devices?

The intent of this criterion was twofold, to establish:

- whether BYO devices had any impact on students accessing and completing digital activities. Students were asked what devices they used and if they had any issues with devices while accessing the activities.
- whether Māori and Pacific students had issues accessing BYO devices not faced by other ethnic groups.

There were very few issues reported that were related to accessing the activities on devices. Those problems that were reported were related to faulty devices or isolated problems with logging onto school networks. The vast majority of participants accessed the activities at school, on a laptop, using a Chrome browser and experienced no problems.

Do the activities provide opportunities for modification and redefinition of assessment questions?

The activities developed were significantly different to traditional written assessments while asking the same style of questions. Using a digital environment, the writers were able to introduce and explain the context in innovative ways. Students could self-check working as they proceeded and to access the second part of questions if they failed to complete earlier parts successfully.

Do the activities encourage the engagement and resilience of students in completing the activities?

The activities succeeded in engaging the participants in the activity. This was a common thread in both teacher and student responses in the survey. The different way the questions were presented to the participants, compared to a traditional examination, was a significant factor in engaging the participants.

The activities were less successful in encouraging resilience. Participants found entering algebraic expressions difficult and this discouraged them from continuing. The teacher interviews suggest that this problem could be alleviated if participants were given more training in how to use the selected digital mathematics tools, in this case Desmos, in particular the MathType feature.

Do the activities support students to maximise their level of achievement?

The innovative ideas used in the design of the activities encouraged students to engage with the activities, but this was countered by the difficulties some students had with the technology. This criterion was investigated by asking students whether they think they would do better when assessed through a digital environment or a traditional environment. Most participants responded that they preferred the traditional pen and paper assessments, although some participants were positive about the experience.

4.15 Evaluation indicators and success

Evaluation question	Criterion or Indicator	Data collection Method	Source of data	Standards (What constitutes success	Response
1. Do the activities provide evidence for the standard at all levels of achievement?	Data reveals whether all levels of achievement are accessible.	Via discussions during development, feedback from critique and teacher surveys.	Teachers, NAF and current panel member	Evidence shows clearly that all levels of achievement are accessible.	Evidence from teachers, developers, materials critiquer and subject experts clearly showed that all levels of achievement are accessible within all three activities.
2. Do the activities provide equitable access to the activities on BYO devices?	Data reveals the benefits and challenges of using BYO devices.	Via end of trial survey	Teachers and students, from the groups Māori, Pasifika and all other.	Evidence gathered identifies benefits of the use of BYO devices and suggests how challenges could be met	In general, there were no problems reported with accessing the activities. Insufficient Māori and Pacific students participated in the trial meaning there was not enough data available to determine if BYOD devices impacted equitable access to the activities.

Evaluation question	Criterion or Indicator	Data collection Method	Source of data	Standards (What constitutes success	Response
3. Do the activities provide opportunities for modification and redefinition of assessment questions?	Data reveals that the questions developed modify and redefine existing patterns of questions.	Via review of final items	Workshop participants and subject matter expert	Evidence highlights how questions have been modified and redefined and suggests how further progress can be made.	The activities modified and redefined questions by: • Beginning with an easy and engaging introduction to the task. • Providing feedback and support for multiple attempts. • Scaffolding and differentiation.
4. Do the activities encourage the engagement and resilience of students in completing the activities?	Data reveals that students were engaged whilst undertaking the assessment.	Via end of trial surveys	Teachers and students, from the groups Māori, Pasifika and all other.	Evidence highlights what secured and maintained engagement from students in the groups Māori, Pasifika, all other,and suggests further opportunities.	The activities did encourage engagement of the participants but were less successful in encouraging resilience.
5. Do the activities support students to maximise their level of achievement?	Data reveals how the performance of students in the groups Māori, Pasifika and all other, compared to that under traditional assessment format.	Via end of trial survey and interview	Teachers	Evidence highlights how student achievement was maximised.	Survey evidence identified that teachers were, in general, more positive about student performance against this criterion of the trial than the students were.

5 Evaluation of the trial process

Was the testing adequate and capable of telling us what we need to know?

The advent of the COVID-19 pandemic impacted on schools' and students' capacity to participate in the trial. This meant it was not possible to gain sufficient data to investigate whether the experience of Māori and Pacific students was different to other ethnicities. COVID-19 had no impact on the other objectives of the trial.

Did the trial test what we set out to test for Māori/Pasifika/all learners?

No. We had insufficient Māori and Pacific learners participate in the trial. The COVID-19 pandemic meant that as schools were self-selected rather than inviting schools that could provide Māori and Pacific student cohorts to provide feedback. Disaggregated participation numbers [of survey responses] were too low for meaningful analysis/conclusions.

In addition, the proposal did not clearly define objectives for testing what contribution the digital mathematics activities could make to equitable outcomes for Māori and Pacific students.

Could we have better identified aspects worth testing for Māori/Pasifika/all learners?

Yes: it would, in hindsight, have been better to work with teachers of these students when planning the trial to incorporate Māori and Pacific student voice into the design of the trial.

Is the evidence robust enough to support reliable decision-making?

Yes, the evidence supported reliable decision making because it clearly showed that students and teachers who completed the survey agreed that the digital activities encouraged students to engage with the assessment. However there was not overall agreement that the activities encouraged resilience. On this basis we have the evidence we need to make decisions about how we use digital mathematics activities for future trials or assessments.

6 Performance against plan

6.1 Review of objectives

The objectives of the Digital Mathematics 2020 Innovation Trial were:

To develop prototype digital assessment items for the assessment of AS91262 – Apply calculus methods in solving problems.	This objective was met by working with an expert teacher development group and a software supplier.
To incorporate digital mathematics tool(s) into digital mathematics assessment for AS91262.	This objective was met. The digital mathematics platform Desmos was used.
To understand how the use of digital mathematics tools enable the modification and redefinition of assessment items.	This objective was met by using an easy introduction to the activity, providing a feedback loop and multiple opportunities to answer the question.
To utilise the opportunities within a digital environment to increase the engagement and resilience of NCEA students when taking part in external assessment.	This objective was partially met.

	The engagement of students when taking part in these digital activities was greater than when taking part in traditional external assessments. The resilience of students when taking part in these digital activities was not greater than when taking part in traditional external assessments.
To use lessons learned from the first digital mathematics trial (2019) to improve the design of activities. Lessons learned included improving the literacy of the questions and only trialling the activities with schools that used Desmos for teaching and learning.	This objective was met, however some students and teachers still reported literacy challenges in understanding what the activity expected of them.
To investigate whether providing digital assessments of mathematics enables equity of access for Māori and Pasifika.	This objective was not met due to the impact of COVID-19 on schools and students. It was not possible to evaluate if the trial contributed to equitable access for Māori and Pacific students as trial design didn't explicitly set out objectives about providing equitable access for Māori and Pacific students.

6.2 Review of benefits

NCEA Online benefits	This trial's contribution to benefit(s)
Students' experience of equitable access and outcomes and relevant credentialed learning sustains their ability to succeed in higher education and the workplace.	The trial resulted in digital mathematics activities which are accessible to students and provide opportunities to meet the national standard. However, teachers and students need support to ensure that students have the necessary technological skills. Once this issue is overcome then digital mathematics assessments are likely to be accessible to a broad range of candidates. It is hoped this will improve equity of access to NCEA external assessment for Māori and Pacific students and provide wider opportunities for students, to succeed.
Sustained confidence in the assessment system as demands of it change.	This trial demonstrated that there is the potential to capitalise on the use of digital technologies to transform assessment and enable students to demonstrate high-level thinking in a greater variety of ways. This will

	help sustain long-term confidence in the assessment system. It would be possible to package three similar activities in such a way they could be used for external assessment under exam conditions.
Greater efficiency and enhanced quality assurance.	The trial demonstrates that mathematics can be assessed digitally. If this can be made easily accessible and widely available then this will contribute to the overall quality assurance and efficiency benefits of NCEA Online.

6.3 Other benefits identified for (potential) realisation

This trial identified the need for professional development and learning for teachers as they are introduced to digital assessment. The development of digital assessment activities offers a unique opportunity to support teachers to develop appropriate pedagogy to support Māori and Pacific students.

This could be realised by working with students and teachers to develop a coherent teaching, learning and assessment package that uses digital activities.

The digital activities that were developed for the trial were recognised by teachers as excellent vehicles for teaching and learning.

7 Impact on related work, planned or underway

Related work	Impact
Where to next for Mathematics and Statistics	Supports the need for PLD to support teachers working in new environments. Closer alignment of teaching and learning with assessment.
Digital tools and applications investigation (including SoNET capability).	Work is currently underway to identify any NCEA subjects where external assessment has not been digitised due to the technicalities and challenges in digitisation. Subjects that require graphing or formula are being considered included mathematics. The outcomes of this project will help inform the next steps for digital mathematics.
New/improved Assessment Master user interface (UI)	Improvements are being made to the Assessment Master user experience. This includes a number of changes to the UI. The outcomes of the digital mathematics activities trial support the importance of an improved user experience. A number of

	students who completed the digital mathematics activities commented on user experience issues with entering symbols.

8 Lessons learned

8.1 For this trial

- For digital assessment to mirror teaching and learning, teachers first need professional learning and support materials that support them to deliver digital teaching and learning.
- Students need comprehensive support to become familiar with the digital environment.
- Clear guidelines and expectations, and where necessary agreements such as memorandums of understanding, need to be agreed on early in the process when working with external agencies, even if there is no payment involved.
- It would be time consuming and expensive for NZQA to try and recreate the sophisticated and specialised functionality provided by Desmos and for any future digital mathematics trials or external assessments, third party support will be required.
- Extending the invitation to all schools to participate in the trial potentially increased the pool of schools that could participate but meant that the cross section of students involved was narrower than needed to provide adequate data for measuring equitable outcomes for Māori and Pacific students.
- More consideration needs to be given to planning for investigating conditions that have an impact on equity

8.2 Generally

- NZQA policies prevent the sharing of documents via Google format.

  For many schools the preferred environment is Google. Transfer from Office 365 to Google can cause problems. This is a significant issue when working with schools and needs further consideration in terms of NZQA policy.
- Documents need stripping of personal information before sharing outside NZQA.
- Zoom and Teams are both good vehicles for remote meetings.

  For this trial Zoom had the greater flexibility and was accessible for more people outside NZQA. Some external people had difficulty accessing meetings via Teams.
- Counter to expectations and previous experience at NZQA, the teachers we worked with preferred to meet remotely from 5 p.m. to 6 p.m.

Appendix One: Initial teacher survey about digital mathematic tools being used for teaching

Mathematics teachers were asked to complete the following short survey to inform the choice of digital environment for the trial.

1. Please select your school/kura from the list below
2. Your role in the Mathematics department
3. Are you completing this survey for Mathematics, Statistics or both?
4. Do you have any comments or feedback on digital mathematics applications you have used for teaching and learning?
5. Do you use any of the following digital mathematics applications for teaching and learning at your school for Level 2 Achievement Standard 91262 Apply calculus methods in solving problems?
    a. Desmos
    b. GeoGebra
    c. Education Perfect
    d. Other
6. Do you have any comments or feedback on digital mathematics applications you have used for teaching and learning?

Appendix Two: Evaluation criteria for digital tools

Criteria	Description
Functionality	The tool must provide functionality to create problems and reimagine calculus problems.
NZ school usage	Teachers and students must be familiar with the tool in order for it to be trialled. Tool familiarity was identified as a crucial issue during the first (2019) trial.
Cost	The tool must be free to teachers and students. Development and other costs to NZQA will be considered.
Accessibility	The tool must be easily accessed by students, especially at BYOD schools where it will be accessed from a number of different devices and platforms.

Appendix Three: Student Survey

Q1 What is the name of your school or kura? Please select 'Other' if your school is not on the list.

Q2 Which school year are you in?

Q3 Which ethnicity do you identify with? Select all that apply.

Q4 What is your gender?

Q5 I think being assessed through digital activities will help me to achieve more than being assessed through a traditional external examination. (Strongly agree to strongly disagree.)

Q6 The digital activities were engaging and interesting. (Strongly agree to strongly disagree.)

Q7 The feedback loops and multiple attempts options helped me complete the problems. (Strongly agree to strongly disagree.)

Q8 The animations and interactive nature of the questions helped me understand the problems. (Strongly agree to strongly disagree.)

Q9 The digital platform encouraged me to keep going and not to give up with the activities. (Strongly agree to strongly disagree.)

Q10 It was easy to draw graphs. (Strongly agree to strongly disagree.)

Q11 It was easy to enter mathematical symbols and equations. (Strongly agree to strongly disagree.)

Q12 It was easy to enter ordinary words and sentences. (Strongly agree to strongly disagree.)

Q13 It was easy to understand what the activities were asking me to do. (Strongly agree to strongly disagree.)

Q14 Did you use a calculator when doing these activities? Select all that apply.

Q15 During the activity did you do any of the following? Select all that apply.

Q16 What sort of device did you use for these activities? Select all that apply.

Q17 What browser or browsers did you use for the activities?

Q18 Did you have any problems with the devices or browsers you used to access the activities? If so please let us know what problems you encountered below.

Q19 Where did you do the activities? Select all that apply - you may have done one at home and one at school for example.

Q20 Did you experience any network or device problems while accessing or completing this digital exam?

Q28 Finally, is there anything else you would like to tell NZQA about your experience with these activities?

Appendix Four: Teacher Survey

Q1 What is the name of your school or kura?

Q2 What role do you have in your school?

Q3 How often have you and your students used Desmos during the teaching and learning for this achievement standard?

Q4 I think most of my students can achieve better with digital activities than traditional (paper) external examinations. (Strongly agree to strongly disagree.)

Q5 My students found the digital activities engaging and/or interesting. (Strongly agree to strongly disagree.)

Q6 I found my students were more likely to keep going and not give up on the digital activities than they are with the traditional pen and paper format. (Strongly agree to strongly disagree.)

Q7 I found the marking schedules easy to use. (Strongly agree to strongly disagree.)

Q8 The activities provided a good opportunity for students to be awarded these grades. Select all that apply.

Q9 Did your students use a calculator? Select all that apply.

Q10 What devices did your students use for these activities? Select all that apply.

Q11 How likely is it that you would recommend these activities to a colleague?

Q12 What did you like about these activities?

Q13 What didn't you like about these activities

Q14 Please give examples of any questions related to the technology that your students asked while completing the activities. For example, questions about computers or Desmos.

Q15 Did any devices work better than others while completing the activities? If so which ones?

Q16 What advice would you give to another teacher who was considering trying these activities?

Q17 Finally is there anything else you would like to tell NZQA about these activities?

Appendix Five: Teacher interview questions

These questions were used with two of the teachers who completed the survey. The teachers were selected at random and the interview was conducted by telephone.

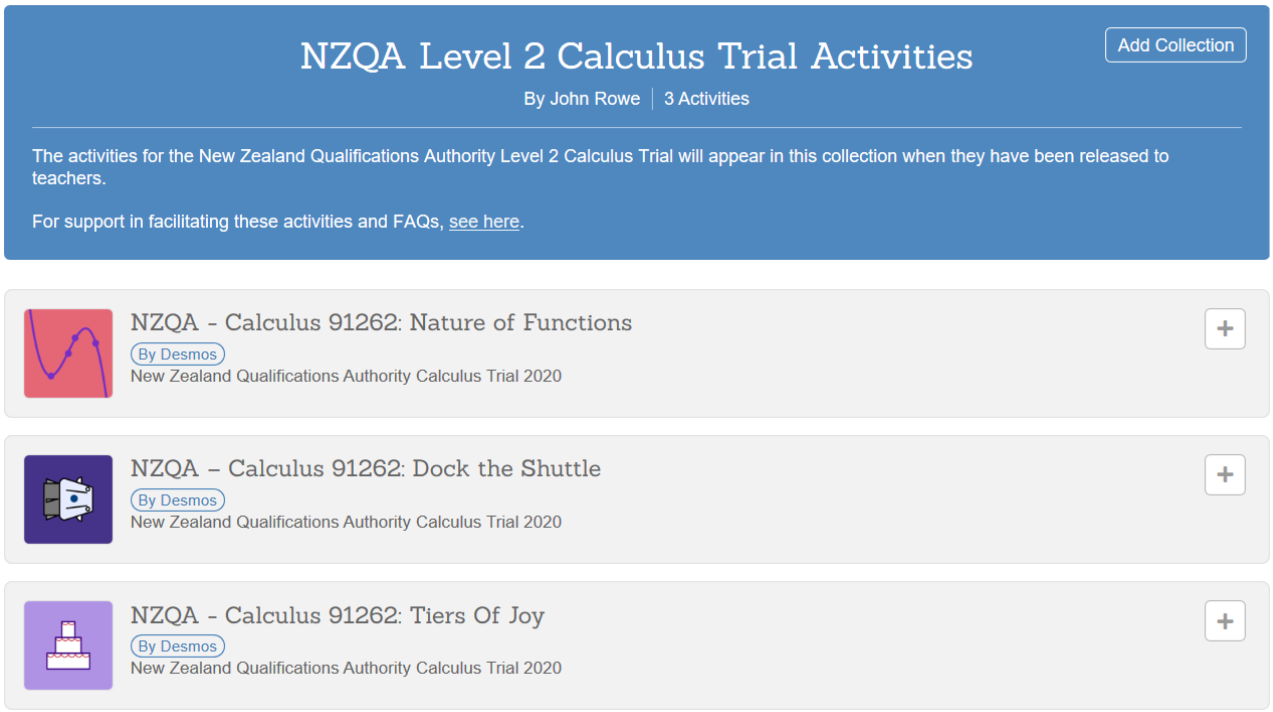
Did you ensure that your students were familiar with Desmos and the MathType function before asking them to complete the digital activities?

Did you suggest or allow them to use pen and pencil to sketch out solutions before entering them into Desmos?

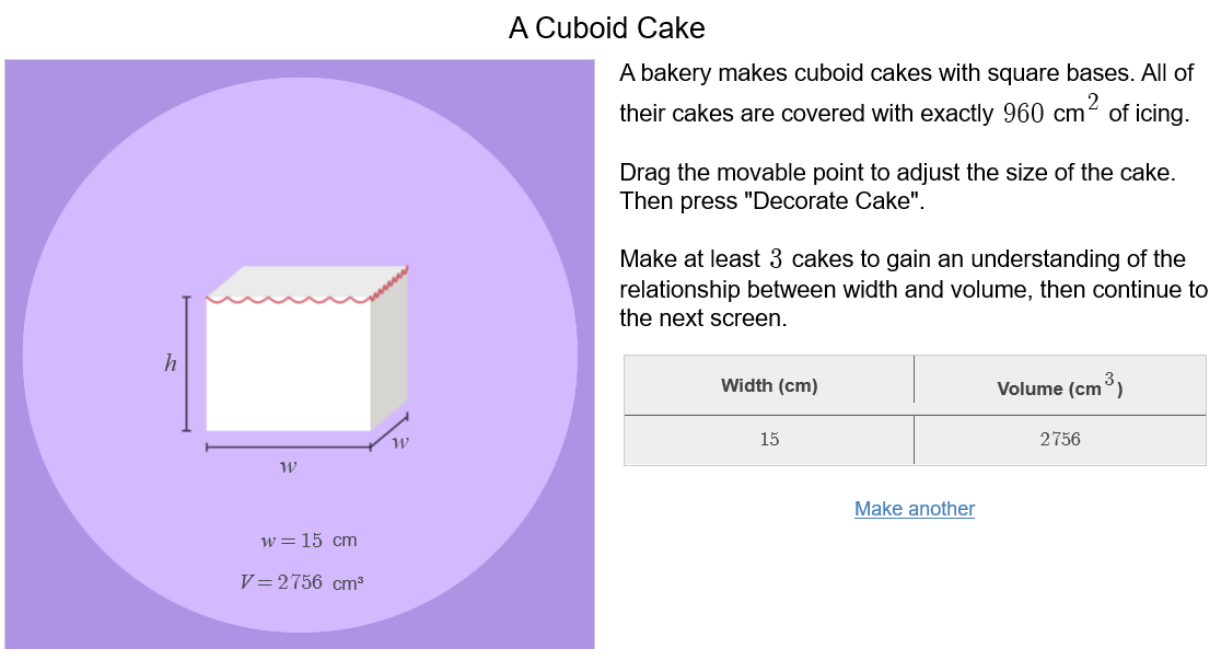
Does your school enter students for existing digital NCEA external assessments? If so, did the students who participated experience one of these digital assessments?

Appendix Six – Digital Activities

Desmos landing page with access to all digital mathematics activities

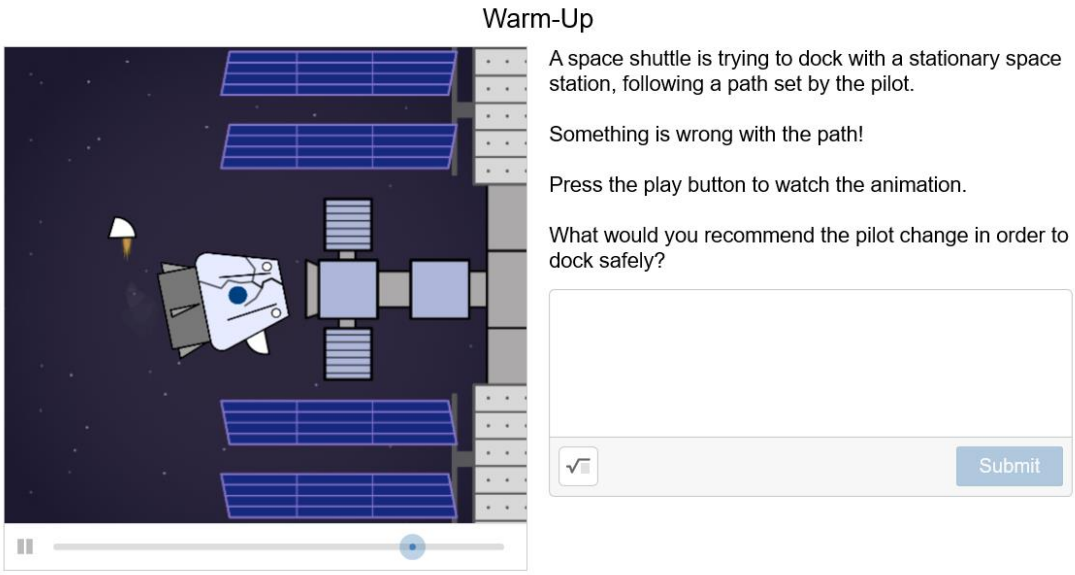


Tiers of Joy



In “Tiers of Joy”, students start by exploring different dimensions of cake as an introduction to the context they’ll be navigating:

Dock the Shuttle



Appendix Seven: Lessons Learned from the 2019 Digital Mathematics trial

i. The tool (Desmos) does not solve the issue of manipulating algebraic equations without the use of paper or a touch screen.

ii. The teacher participants were improving their knowledge of how to use the tool whilst developing assessments which met the requirements of the Achievement Standard. Some questions contained higher levels of literacy requirements than those normally found in external assessments. The formatting of the questions could have been improved, so all aspects required to answer the question are easily accessible to students.

iii. Teacher participants focussed on developing assessments which mirror current paper assessments to ensure that they would assess against the Achievement Standards. This restricted their work. There is the need to re-imagine questions. Digital assessment offers a limited advantage for Substitution and Augmentation, it offers a greater advantage for Modification and Redefinition in the SAMR continuum. Non-timebound assessments may also provide a better opportunity for Modification and Redefinition.