CASE STUDY

A Trial of the Assistive Technology EquatIO in an Irish University

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Abstract

In this case study, we report on the trial of the assistive technology EquatIO with students studying mathematics and statistics at Maynooth University (MU) during the 2021-22 academic year. This software, provided by the MAP (Maynooth Access Programme) Office, was made available to support students who presented to MAP with a difficulty writing mathematics. In this paper, we give a brief outline of EquatIO and the trial. We then describe the feedback received from students who engaged with the software. Finally, we close with conclusions on our experience of providing the software for students, including observations from the tutor who assisted students as part of the trial, and end with our recommendations for possible future supports.

Keywords: Accessibility, Assistive Learning Technology, Mathematics Support.

1. Introduction and background

In 2019, MU received funding from the Higher Education Authority (HEA) in Ireland for an ICT and STEM Enhancement Project. As part of this project, the Department of Mathematics and Statistics at MU has considered different aspects and new trials of academic mathematics learning supports (MLS) provided for students with different access needs registered with the MAP Office. These include mature students and those with disabilities and additional learning needs, see for example Heraty, et al. (2021), Mac an Bhaird, et al. (2022a), and Mac an Bhaird, et al. (2022b). For further detail on accessibility issues related to MLS and service mathematics teaching see, for example, Cliffe, et al. (2020). In 2021-22, the MAP Office in collaboration with the Department of Mathematics and Statistics, piloted the software EquatIO with students who needed additional support for mathematics. For further information on the use of assistive technologies in higher education in Ireland see, for example, McNicholl, et al. (2020) and McNicholl, et al. (2021).

2. EquatIO

EquatIO (texthelp.com/products/equatio) is software offered by the company TextHelp, whose reported mission is to provide accessibility through their suite of assistive technology. EquatIO is specifically designed to be used for STEM subjects and is marketed with the description: "*Makes math both digital and accessible. Type, handwrite, or dictate any expression, with no tricky coding to master*". When opened, EquatIO launches a toolbar which is displayed at the bottom of the screen (see Figure 1), in which, mathematical expressions can be created and then inserted into a document.

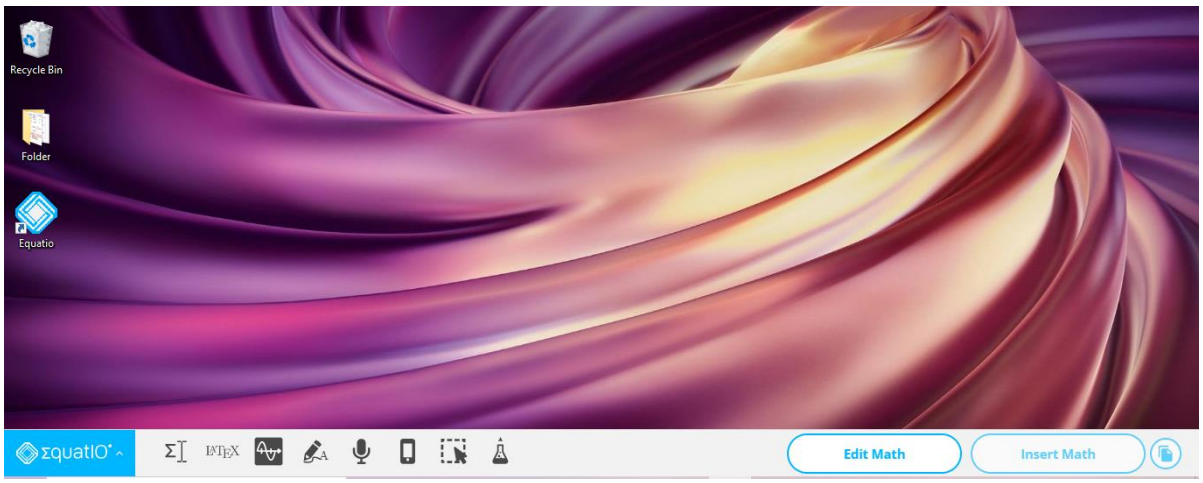

Figure 1: EquatIO Toolbar

The Windows and Mac version of EquatIO, when opened, displays over any other open application and can be configured to insert the mathematical expressions into a Microsoft Word document (on Windows and Mac) or Microsoft PowerPoint document (on Windows only). The Google Chrome version of EquatIO displays in a Google Chrome window and mathematical expressions can be inserted into a variety of Google and Microsoft online file types (such as Google Docs and Microsoft Word Online), full details are available (https://www.texthelp.com/products/equatio/equatio-free-vs-premium/). Other versions of EquatIO were not considered during this trial.

Users of EquatIO can create mathematical expressions in a variety of ways, for example, by typing, handwriting, speaking or through the screenshot reader. Mathematical expressions can be typed into the 'Equation Editor' where symbols are suggested to the user as they type. For example, typing the word "*sum*" displays three suggestions: sum $+$, summation $\sum_{n=}$ and sum of two cubes $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$ (see Figure 2). The mouse or the navigation and enter keys are used to choose the desired option. There is an extensive range of options available such as notation for integrals, limits and matrices, Greek letters, and many common mathematical, statistical and even physics and chemistry-related equations.

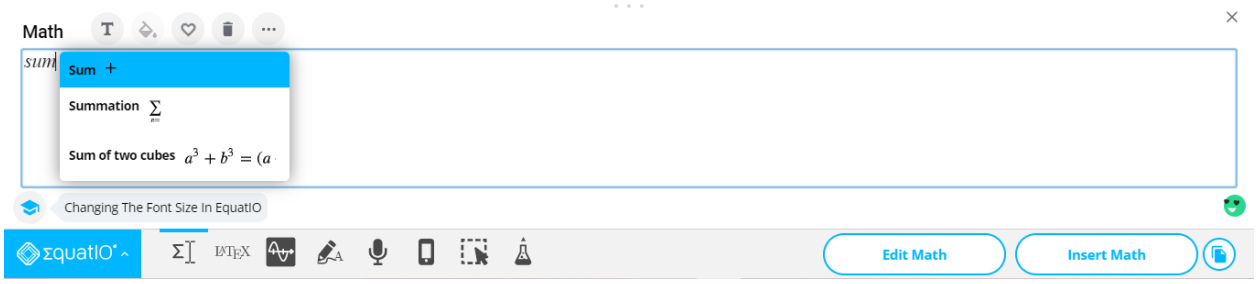

Figure 2: The Equation Editor

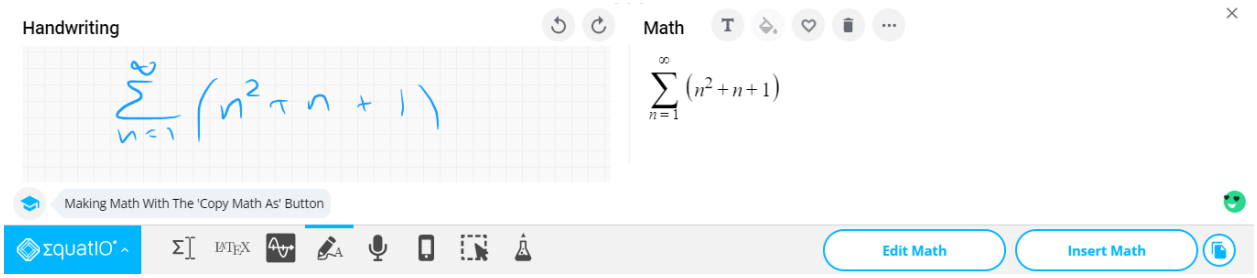

Figure 3: Handwriting Recognition

The ‘Handwriting Recognition’ option allows the user to write maths into a small digital whiteboard, which EquatIO then converts into text (see Figure 3).

The ‘Speech Input’ option recognises spoken mathematical expressions and converts them into text (see Figure 4). Note that EquatIO is designed to ignore any words that it does not consider to be mathematical expressions.

The ‘Screenshot Reader’ option lets the user capture any mathematical expression existing on their computer screen, in either text or image format, by drawing a box around it with a crosshair cursor. This can then be edited in EquatIO (see Figure 5). This feature also gives the user the option to hear the expression being read aloud.

While mathematical expressions are being created, using any of the previously mentioned methods, EquatIO will automatically generate the LaTeX code of the corresponding mathematics which can be viewed and edited in the ‘LaTeX Editor’ (see Figure 6). The user has the option to edit this LaTeX code and swap back to the Equation Editor to edit further, however, the Equation Editor is not compatible with all LaTeX. Some advanced types of LaTeX will turn the little happy green face to yellow, and warn the user that their math is “*advanced*”. In this case, the Equation Editor can no longer be used and the user must proceed with LaTeX. We did not come across any such situation with the mathematics that our students encountered.

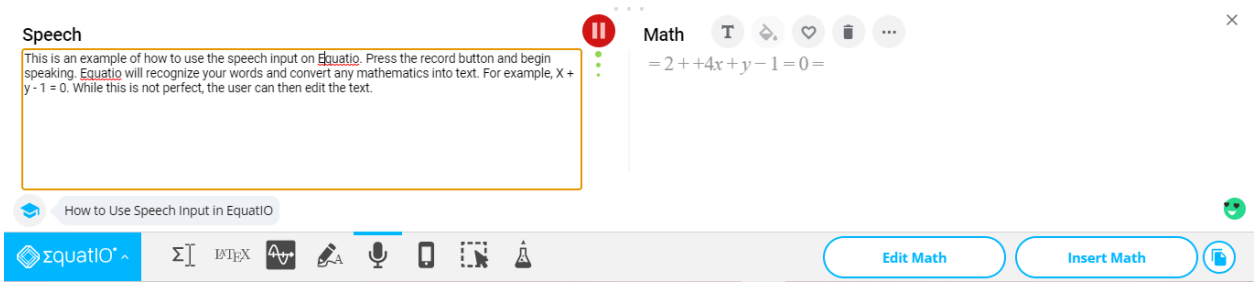

Figure 4: Speech Input

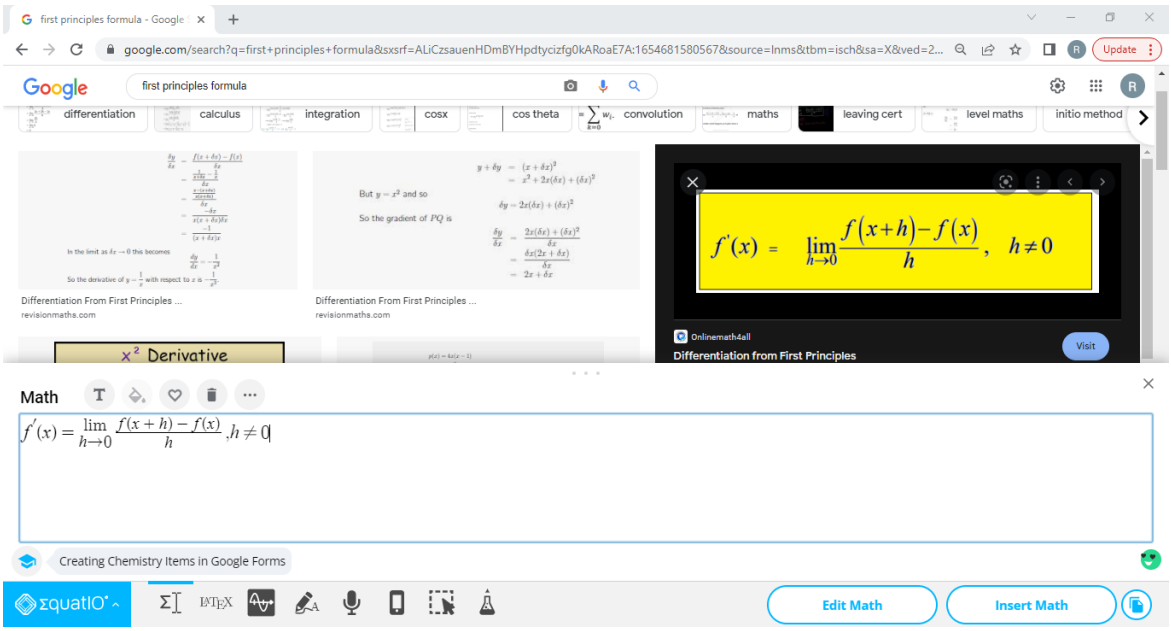

Figure 5: The Screenshot Reader

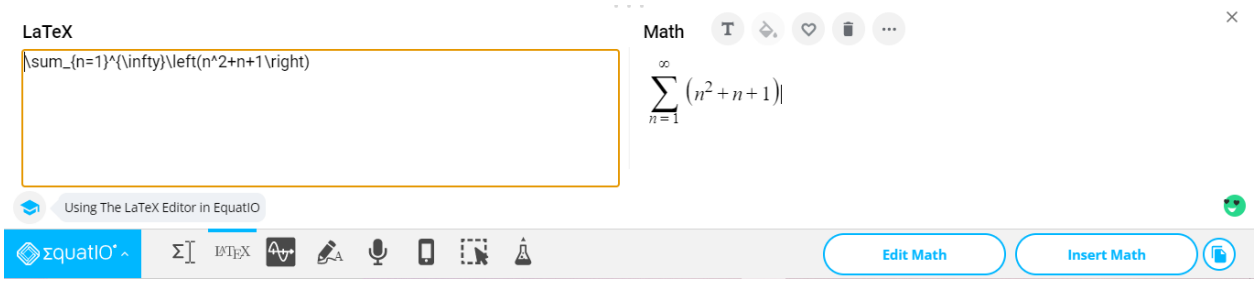

Figure 6: The LaTeX Editor

$$\sum_{n=1}^{\infty}\left(n^2+n+1\right)$$

Figure 7: Image of an Inserted Mathematical Expression

Figure 8: Copy Math As

Clicking 'Insert Math' inputs the mathematical expression as an image by default into the current selected compatible document type (see Figure 7). Clicking on an inserted image and then choosing 'Edit Math' returns the text of that image to the Equation Editor.

If the user wants to use an incompatible document, then the 'Insert Math' and 'Edit Math' buttons won't work. To place the mathematical expression in an incompatible document they must copy the expression using the 'Copy Math As' button, and then paste it into their document. This allows the user to copy the mathematical expression to the clipboard in a variety of formats and gives options of Image, LaTeX, MathML, Spoken Text, HTML, SVG, URL and Download PNG (see Figure 8).

EquatIO has a 'Graph Editor', which will create graphs based on user input. These graphs can also be inserted into documents. There is also an 'EquatIO Mobile' feature which allows for the use of a mobile phone for handwriting-to-text, speech-to-text and image-to-text. This creates mathematical expressions which can be inserted directly into any compatible document which the user is currently editing. This feature is accessed through scanning a QR code, and signing in on a mobile, but no download is necessary.

3. Methodology

Each Department at MU has a MAP Academic Advisor who acts as a point of contact for MAP staff and students. The first author has had that role for the Department of Mathematics and Statistics (the

Department) since 2012, see Mac an Bhaird, et al. (2022a) for further details. There is an established and successful referral process for the Department and the MAP Office in relation to MAP students and the provision of academic MLS. We decided to run the trial by embedding EquatIO as part of this process.

In the first instance, when students attended a meeting with their contact in the MAP Office, those identified with issues relating to the writing of mathematics, for example, speed of writing, clarity, organisation, etc. were referred to the Assistive Technologist (AT) specialist, the third author. The specialist would make students aware of various ATs available and where appropriate, mention the possibility of support with EquatIO and provide a link to the software along with a referral to the MAP Academic Advisor in the Department. During the 2021-22 academic year, nine students in total were referred for support using EquatIO, three of these did not respond when subsequently contacted by the MAP Academic Advisor and then contacted again by the AT specialist.

When the students met with the MAP Academic Advisor, in addition to the standard discussion about the student's progress with mathematics and the various MLS available, they were provided with additional information on EquatIO. In particular, it was clarified that a tutor (the second author) would be available to meet with the students and support their initial engagement with the software. Students were then also informed about the trial, the option of providing feedback about their experience, and that the tutor would keep notes about the sessions. It was also made clear to the students that a decision to engage or not engage with the trial would not impact on the support provided with EquatIO in any way. All six students were provided with full information on the project, including details of the ethical approval that was granted in October 2021, and all agreed to engage with the trial and provide feedback. In March and April 2022, students were issued with a short open response survey, see the appendix. Once responses were completed, the data was then anonymised for the reporting process.

4. Student Feedback

In this section, we provide an overview of the feedback collected from the six student participants in the open-response questions. Five of the participants were first-year students, two of which were mature students, and the final participant was a third year mature student who was the only one who had previous experience using LaTeX to write mathematics.

Three of the six participants indicated that, prior to being introduced to EquatIO, they had already used AT. One of these students mentioned using ATs in secondary school, but not for mathematics. The remaining two students had previously used ATs at university, but again, neither of the technologies mentioned - Read&Write (texthelp.com/products/read-and-write-education) and a Livescribe Pen (eu.livescribe.com) are specifically designed to help with mathematics. Read&Write supports students with reading and writing text whereas Livescribe Pen supports students to cope with note-taking.

All six participants indicated that, prior to this trial, they had not previously heard of or used EquatIO. In addition to the two ATs mentioned above, students described other types of assistance and technologies that they had free access to in school/university. For example, they benefited from writing courses, the note-taking software Glean (glean.co), a laptop, a Special Needs Assistant, a scribe, and exam provisions such as extra time and being allowed to type exams.

The participants reported various personal barriers to studying which they hoped EquatIO would help with when they were first informed of the technology. Saving time when writing was mentioned by four, "*I hoped it would speed up my note-taking process*". Three participants explained having difficulties with handwriting, "*I have trouble writing, I can write, but very slowly and it's very hard to read it*". Two participants mentioned wanting to use EquatIO specifically for taking down notes during lectures, "*Part of my difficulty is that in a typically fast-paced lecture I find it difficult to pay attention in a productive fashion to the aural content of a lecture if I am being asked to also write down a lot of content from a*

board or slides simultaneously". Finally, one student mentioned that they hoped it would make it easier to keep their notes organised.

Participants were also asked to describe how they used EquatIO, if at all, after being introduced to it and given a demonstration of how to use it. Only one student reported using EquatIO regularly, and that was to take notes during lectures. Although this student reported not having used AT before, their feedback was that "*It's a lot quicker than having to write down notes and is easier to read*". Of the remaining five students, only two mentioned using EquatIO occasionally, and this was specifically to use the graphing function. Reasons cited for not using EquatIO included that it did not save time, "*I hoped that EquatIO would help with my time management, however when I used EquatIO it took me about the same time to capture my notes as it would have taken if I had written them*", that it did not work with their device, "*It was frustrating. I tried to use it but it wasn't working*", and that they didn't have time to use it "*I have not used EquatIO much yet as I was introduced to it during a busy period of study and feel that I need to spend time to get familiar and comfortable with it before I can be happy with using it on a regular basis*". For the third-year student it wasn't the right tool for them, "*I had developed my own strategy for notetaking using LaTeX which I had grown to prefer and after trying EquatIO a couple of times I decided I didn't have the time to learn another tool when I had a perfectly good one already*".

Participants were asked to comment further on the pros and cons of using EquatIO. One student left this question blank, one said they had no strong opinions, and one restated their frustration with using the software that did not work for them. The other three students gave pros to using EquatIO. Again, the graphing feature was mentioned, "*The graphing function was helpful, I could click into the function and output graphs into a word document easily*". One participant, the only regular user of EquatIO, remarked that it was quicker than writing and easier to read. And, although they did not use EquatIO themselves, the ability to be able to create typed notes was praised by the third-year student, "*It is a very useful tool in terms of being able to write notes and immediately transform those written notes into a nice-looking typeset collection of notes. While typing notes with something like LaTeX is definitely effective, writing out notes particularly in Maths is beneficial for understanding and for practice. EquatIO in this regards is a powerful tool*".

The participants were asked, if they were not using EquatIO regularly, to explain why. Five participants responded. Three of the participants cited time-related issues: two of these reported not having the time to dedicate to learning a new technology "*I haven't had time to sit and familiarise myself with it as fully as I would like*" and "*I didn't adopt it early enough in my studies and the pace of my studies are too fast to allow me to take time to integrate a new tool*". The third of these found EquatIO time-consuming to use as it was not directly compatible with their existing study strategies, "*I find it takes longer to copy and paste and input into notes like OneNote. It ends up taking more time than writing*." Another student mentioned that a change in the format of their mathematics lectures meant they did not need to take notes in the same way and had no need for EquatIO. Finally, one student reiterated their frustration that the software would not work on their laptop. The student who did use EquatIO regularly did not respond to this question.

When asked if they thought that this software would be useful for other students, five participants agreed. They suggested that other students would find EquatIO very beneficial, even though it was not necessarily useful for them, "*This would be a fantastic tool for Maths students particularly if used in conjunction with LaTeX, if integrated from the beginning of a student's course*".

5. Conclusion

A number of positives and negatives emerged from this trial of EquatIO. For example, the students generally found it easy to use, with download and installation normally fast and straightforward,

reducing the barrier to learning a new technology. EquatIO has a simple interface and, with some instruction, most students began using it and creating documents quickly. One caveat is that EquatIO inserts images by default, these can appear pixelated and the text in the various images can have different sizes. However, while typed documents have better appearance, the ease-of-use with EquatIO's default image insertion is a good trade-off. In our institution's Mathematics and Statistics Department, for assignments which are required to be submitted online in PDF format, students are advised to hand-write their assignment, take pictures of each page, and then convert their work to PDF format using an image to PDF conversion application. For this reason, assignments created with EquatIO have perfectly satisfactory presentation, even with some pixelation or distortion. Furthermore, the cohort of students who we would be directing to use this software would predominantly be first-year, at-risk, disabled or otherwise disadvantaged students, therefore, improving presentation beyond an already more-than acceptable level would not be a priority.

To maximize the student learning experience, an important focus of this project was to attempt to integrate EquatIO with their existing study strategies. While each student had unique strengths, they encountered different barriers when studying and they were already using a variety of supportive tools such as OneNote, Word, PowerPoint, LaTeX, Glean, Read&Write and Livescribe pens. Some of the students preferred handwriting while others typed, and this meant that, although it brought some useful features, EquatIO did not always fit smoothly into their study techniques. As a result, the second author's meetings with individual students to discuss EquatIO were very important. This facilitated greater insight into students' study techniques, the issues they were encountering within their modules and, as a consequence, the second author could offer students personal advice on various features of EquatIO and suggest ways that they could try to use it to suit their individual needs.

From these meetings and survey responses, it is clear that time management was of huge importance to the students. They each reported seeking ways to reduce the time they spent on mathematics because of the individual time-consuming barriers they encountered while studying. Learning how to use a new technology is, in itself, time-consuming and, for this reason, the meetings with the students were important to help guide them through the downloading, installation, running, and use of EquatIO. The second author also created a video, personalized to MU students, which covered these aspects of EquatIO and streamlined the process. Unfortunately, after set up, for some of our students, using EquatIO ended up being more time-consuming than their previous methods. For example, several students already used OneNote, which is not directly compatible with EquatIO. As a result, they had to copy and paste every expression they wrote. The extra time it took students to copy and paste each equation resulted in their return to handwriting, as that was faster and more accessible for them.

During our trial, we also found that EquatIO had a number of bugs, which we tried to resolve during the student tutor meetings. Many of these bugs appeared minor and had a work-around. For example, occasionally the Equation Editor would not let the user type inside it. In order to fix this issue, we discovered that first hiding and then un-hiding the Equation Editor allowed the user to type again. One of the participants also experienced a separate issue which we could not solve within a short timeframe, and this appeared to be unique to their device, which was new. When they tried to insert a mathematical expression created in EquatIO into a word document, the image appeared as a black box with no text displayed.

None of the first-year students reported having previously used ATs that were specifically designed for mathematics or STEM subjects. Prior to this trial, we had sporadically tried to introduce LaTeX to individual first-year MAP students who were struggling to write mathematics. These unstructured attempts were rarely successful and LaTeX appeared to be too advanced for these students. However, EquatIO does offer a first look at mathematics in a variety of coded formats such as HTML, MathML and LaTeX which students can build-on as they progress through their course. This means that

EquatIO would remain useful to students throughout their course, and they would not necessarily need different software as their skills improve. Developing the skills to create mathematical documents that are in coded rather than image format would be easier to edit and lend themselves better to writing documents collaboratively. Interestingly, creating documents with these more advanced skills would increase accessibility, as equations in coded format have more options for compatibility with immersive readers.

It appears, based on student survey responses, that only one student used EquatIO to any significant degree during our trial, writing up notes in lectures. However, we know from this student's comments in meetings with the second author that they also used EquatIO to complete some assignments which they were able to submit in PDF format. During the 2021-22 academic year, the majority of first-year assessments were multiple choice Moodle Quizzes, and there were only three assignments due in PDF format, which is probably why EquatIO was not a focus for most of the first-year students. It seems those few PDF assignments did not warrant the initial investment of time it takes to learn how to use a new software.

In 2022-23, almost all the first-year mathematical assessment at MU will be PDF upload, and we believe that this will incentivise more engagement from MAP students with EquatIO due to the ease with which mathematical documents can be created. The point remains, however, that it is also crucial to have a staff member available to meet with and advise students regularly on how to use EquatIO effectively for their own learning needs. Thus, for any institution considering making EquatIO available for their students, we recommend that they carefully consider both their capacity to assign staff to ensure that students receive on-going support with the software and the modes of assessment being used.

6. Acknowledgements

This study is part of the MAP Office's initiative to offer the latest AT tools for its students and assess their impact. It is also part of the ICT and STEM Enhancement Project at MU funded by the HEA. Ciarán Mac an Bhaird is the lead on the mathematics strand of this project, and Rachel O'Neill's position was fully funded by the HEA. Ruchi Palan is the assistive technology tutor at MAP and supports students with their AT needs.

7. References

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8. Appendix

1) Prior to being introduced to Equatio,

had you used any other assistive learning technologies? If so, what were they, what did you use them to help you with? Was this in school\university etc?

had you heard of Equatio or ever used it? If so, what did you know about it, what did you use it to help you with? Was this in school\university etc?

2) When you tried to use the assistive technology, what were you hoping that it would help with (e.g. don't like writing, time management, etc.....)

3) Apart from assistive learning technologies, did you get any other type of assistance with writing at school or university? If so, what was the assistance, did it help? etc.

4) Following you introduction to Equatio, and the session(s) with Rachel, what (if anything) did you use Equatio for? Was this only on one or two occasions or did you continue to use it on a regular basis?

5) How did you find Equatio to use, positives\negatives etc. What is it about Equatio that is helping you (if you are one of those using it regularly)?

6) If not using Equatio regularly, why not?

7) When compared to other technologies available\that you use, do you think Equatio is a software that should be made available to students in future years or are other existing technologies sufficient?

8) Any other comments ?