

# Master's students' perceptions of Microsoft Word for mathematical typesetting

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## Abstract

It is widely recognized that mathematical typesetting is more difficult than typesetting in most other disciplines due to the need for specialised mathematical notation and symbols. While most mathematicians type mathematical documents using LaTeX, with varying levels of proficiency, students often use other options or handwrite mathematics. Here, we investigate students' perceptions of the mathematical editor available since Word 2007. This investigation is timely as there is anecdotal evidence that mathematicians do not think that Word is capable of quality mathematical typesetting, and there have not been many studies in the literature on this topic.

In this case study, we ask the following questions: Is Word a suitable tool for students to typeset mathematics? And: How does Word compare to other mathematical typesetting packages students have used? We asked Master's level students to typeset mathematics in Word and then comment on their experience, relating to the ease of use, quality of output, and overall experience. We also asked the students to compare Word to other tools they may have used in the past.

The results show that the current versions of Word are indeed capable of producing quality mathematical typesetting, that the learning curve is not high, and that Word should not be dismissed as a tool for typesetting mathematics. While there were concerns that editing takes longer than in other tools and that typesetting in general takes time, overall students were positively surprised by Word's mathematical features and commented favourably.

## 1. Introduction

Throughout all levels of education, students produce mathematics assignments by hand. Indeed, writing mathematics by hand, and doing so quickly and legibly is a necessary skill as students are traditionally required to do this in examinations. However, at some point in their tertiary education, many mathematics students are also required to submit project reports or theses as typeset documents just like professional mathematicians. Producing typeset mathematics is significantly harder than producing documents containing only text due to the need for mathematical notation and the range of special symbols used.

Traditionally, teaching students how to produce such documents may not have been a high priority for educators, but this is now changing and these skills are being viewed as essential to the graduate mathematician as we will detail below. Many institutions are beginning to include such skills in their curriculum. For example, Gray and Costanzo (2003) describe the introduction of a mathematical typesetting module at Pennsylvania State University.

The increasing use of Virtual Learning Environments (VLEs) in many institutions also provides pressure for students to communicate mathematics in ways other than handwritten script. For example, many VLEs support the ability for students to submit assignments electronically, as an uploaded document. Many institutions are moving towards this as the primary means of submission.

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Reasons for this, as reported by Brodie and Loch (2009), include financial savings and a reduction of turnaround time for assignments. A faster turnaround, in turn, leads to educational benefits such as faster feedback, which is critical if students are to benefit from the feedback they are given (Gibbs and Simpson, 2004-5).

The production of electronic assignments by students in disciplines where the majority of communication takes place using plain text can be quite straightforward, but assignments containing substantial amounts of mathematics are more problematic. Although the electronic submission of assignments does not *ipso facto* mandate electronic preparation of assignments (some students may prepare their assignments by hand and then digitise them prior to submission), many students choose to prepare typeset documents.

For distance-learning universities such as the UK's Open University (OU), electronic assignment submission allows streamlining the handling of paper-based assignments. Indeed, the OU introduced electronic assignment submission on its mathematics master's programme in 2009 (Jordan, Arrowsmith, Lowe and Mestel, 2010). While the electronic marking of electronically submitted assignments in mathematics has been researched in some detail at the OU (Lowe, Mestel and Arrowsmith, 2007; Mestel, Arrowsmith and Lowe, 2008; Jordan, Arrowsmith, Lowe and Mestel, 2010), there have been few studies specifically on the problem of insertion of typeset mathematical formulae by a student into an electronic assignment document.

In 2007, Microsoft introduced version 12 of its Office package, the word-processing element of which, "Word", included a revised mathematical typesetting environment (known as the mathematics ribbon) which is further described below. Subsequent editions of Word have maintained this mathematics ribbon, in particular Office 2010 (which extended the ribbon to PowerPoint) and the most recent Word 2013. For mathematics educators, it is of especial interest to discover whether the new mathematics capability of Word would help students produce typeset assignments.

In this paper, we report on a study that investigated OU master students' views of the mathematical typesetting capability of Word - and future prospects for the use of Word by postgraduates. We begin with an overview of mathematical typesetting for students. After a discussion of the context to the study, we describe the methodological approach taken. Following the presentation of our results, both quantitative and qualitative, we conclude with a summary and a discussion, and highlight opportunities for further research.

## **2. Background – mathematical typesetting options for students**

There are two basic approaches to producing typeset mathematical notation on a computer: either to encode the notation using a linear syntax that is then interpreted by some system, or to use a graphical user interface that typically consists of various palettes of symbols and mathematical structures which are selected by the user using a mouse. The structures generally contain placeholders that can be occupied by other structures or symbols. The graphical entry approach is often easier for the beginner to use, but, since it necessitates constantly selecting items from different menus or palettes, interspersed with typing characters using a keyboard, it can be slow and hence frustrating to the more expert user.

The first, typed, approach is exemplified by the TeX mathematical typesetting system (<http://tug.org/>), and, in particular, the macro package LaTeX (<http://www.latex-project.org/>). This has for many years been the dominant technical typesetting environment used by professional mathematicians, physicists and computer scientists, amongst others. Although there are palette-based front ends such as Lyx (<http://www.lyx.org/>) and templates to assist data input in packages such as WinEdt (<http://www.winedt.com/>), LaTeX remains largely a text-input based system. In

addition to the typesetting of mathematical equations, LaTeX also offers other features often used by mathematicians, such as automatic numbering of equations, and the ability to easily refer to such equations.

The experiences of Gray and Costanzo (2003) show that learning to use LaTeX proficiently is not a trivial task that can be completed easily by skimming through a manual or attending a short training session, but rather it requires some significant effort and time commitment from the learner. Confirming this view, Hughes and Sanchis (2004) believe that “only the most motivated students can become proficient at TeX on their own” (p.143), and suggest the provision of some amount of formal training in the use of TeX. It is interesting to look back to this paper written in 2004 when there was “no current solution” that was “universally superior” (p.139). This has not changed despite major advances in technology, leading to the now ubiquitousness of tablet devices that provide additional input options.

The graphical approach to mathematical typesetting is typified by the “Equation Editor” in Word prior to its 2007 edition, which used a separate window for mathematical input and editing. Whilst this has been traditionally viewed by many professional mathematicians as awkward to use, it has been popular amongst the general student community. Another popular graphical editor is MathType (<http://www.dessci.com/en/products/mathtype/>), which links into Word. Topping (1999) describes MathType and its ability to act as “an interactive front-end to TeX authoring” by converting typeset mathematical formulae, or entire documents including some formulae, into LaTeX or (Presentation) MathML (<http://www.w3.org/Math/>) formats. The process of creating mathematical formulae in MathType and converting and pasting these into a TeX document, however, appears to be laborious.

Lo, Edwards, Bokhove and Davis (2013) conducted an online survey of 80 UK-based mathematics teachers and postgraduate students on their levels of confidence and competence using certain commonly used input methods, with the result that Word ranked highest for confidence and competence levels, followed by LaTeX and MathML. This survey did not focus specifically on long mathematics assignments. It shows some similarity to the study we report on in this paper.

Electronic handwriting recognition of mathematical writing has been discussed for more than two decades and is not a simple task, as both character recognition and mathematical structure recognition need to be performed, see the paper by Toyozumi, Suzuki and Mori (2001) and references therein. Although the recognition has improved significantly and recent versions of the Microsoft Windows operating system even contain a “Math Input Panel”, the quality of recognition is less than perfect. We agree with the views expressed by Smith and Ferguson (2004) that there is a need for a new approach to communicating mathematics online since it is “even more difficult, almost impossible, for students to respond with formulas and diagrams” (p.681) in mathematical e-learning.

The mathematics editor, known as the equation ribbon, first introduced in Word 2007, is not only fully integrated into the software but also offers the user the choice between a typed-syntax (similar to LaTeX but with some differences) and a graphical input approach using an enhanced palette with an extensive set of mathematical characters, structures, and the possibility of storing equations in a gallery for future retrieval and re-use. The quality of the mathematical output was significantly improved with a new Cambria Math font and glyph positioning on par with LaTeX. For clarity, in this paper we refer to all versions of Word with the enhanced mathematical typesetting capability as Word, without qualification. When required, we shall clarify the specific version of Word, and, in particular, we shall always make clear when we are referring to a pre-2007 version of Word.

### **3. Methods**

We will now provide details on the context for this study, and describe the methodology used.

### *3.1 Context*

The Open University is the UK's largest distance learning university with currently 14,000 undergraduate and 800 postgraduate students studying mathematical sciences modules. The vast majority of students study part-time, through the University's system of "open learning". Assessment is through assignments and a final examination.

About 500 students are studying on the OU's postgraduate Mathematics Master of Science (MSc) programme each year, in which students take six modules, including a final dissertation. Some students have graduated from the OU's Mathematics undergraduate programme, but most have diverse academic backgrounds, and many have not studied mathematics for several years.

Following a pilot project, in 2009 the OU introduced electronic submission of assignments into its mathematics master's programme (Jordan et al., 2010). Participation by the students was encouraged (but not compulsory) and take up was initially only about 28%. However, student participation later rose rapidly so that, in 2011, 63% of all assignments submissions were electronic, after which the university decided to make electronic submission compulsory for mathematics master's students. Recently, the university has decided to introduce electronic submissions also in its mathematics and statistics undergraduate programmes from 2014 onwards. The introduction of electronic assignment submission in the master's programme provided a timely opportunity to investigate Word's capabilities.

### *3.2 Methodology*

In 2010, a year before electronic submission of assignments became mandatory, students enrolled on the OU's MSc programme were invited to participate in a study on the mathematical typesetting capabilities of Word 2007 and, in particular, of its utility for authoring student assignments.

Participants were first asked to complete an initial online questionnaire covering their previous experience with mathematical typesetting. Afterwards the students were provided with a licensed copy of Word 2007 to keep for their private use after the end of the study, together with a brief introductory guide to its use. The students were then asked to use the software either to author at least one student assignment, or to input several pages of other mathematical work. This second option was provided because not all the participants in the study were submitting assignments electronically. Finally, participants were asked to complete a second survey on their experience of using the mathematical tools in MS Word.

In this paper, we adopt a mixed methods approach, encompassing analysis of both quantitative and qualitative data from the two surveys to address the following two research questions:

1. Is Word a suitable tool for students to typeset mathematical assignments?
2. How does Word compare to other mathematical typesetting packages students have used?

We undertook a thematic analysis of the open-ended student comments. The qualitative responses have been used to support the quantitative responses. We use a case study approach in this paper, as we are interested in 'process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation' (Merriam, 1998).

## **4. Results**

To correlate answers between the first and second anonymous surveys, participants were asked to input a code phrase into both surveys. Survey 1 was taken by 39 students, however, only 24

students could be identified from these who also completed survey 2. We therefore limit our data analysis in the following to the answers of the 24 students we could match across the two surveys.

#### *Student background and previous experiences with mathematical typesetting*

We first present the results on the background of the participants. Students' self-perception of their computing skills was high, with 17 categorising themselves in the 7 – 10 range, on a Likert scale of 1 to 10, where 1 is a 'beginner' and 10 is an 'expert'. Table 1 details student responses regarding their previous use of several major software packages handling mathematical notation.

**Table 1 Previous use of mathematics input software. Note that more than one answer was possible.**

Previous mathematics input software used	No. students
MS Word 2007	7
LaTeX	11
Earlier versions of Word & Equation Editor	16
Earlier versions of Word & Mathtype	3
Maple	2
Open Office	2
Mathype standalone	1
Mathcad	1

We note that a significant number of the group (7) had previous experience of the mathematical capabilities of Word and at least 16 had used earlier versions of MS Word (together with mathematical input tools). We realise that this might bias the results in favour of MS Word.

We also note that 11 of the 24 participants had had prior experience with LaTeX, which is of itself unusual in a student group, even at master's level. Whilst this provides an excellent (and rare) opportunity to compare student experiences of Word and LaTeX, this does suggest that the participant group had an interest in mathematical typesetting over and above the average master's student in mathematics. This may not be unsurprising since these students were studying a high-level mathematics course at a distance-learning university. It was, however, interesting to see that 15 of the students had in the past submitted assignments electronically, 13 using typeset mathematics and 2 using scanned handwritten mathematics.

We now turn to the second survey, which was taken at the end of the semester, after a period of experimentation and learning with Word by the participants.

#### *4.1 Student use of Word for mathematical typesetting*

To introduce students to mathematical typesetting in Word, a short guide to the mathematics ribbon was provided for the students, which 19 considered sufficient, although the other 5 would have preferred more training materials, for instance with more examples. Some students said they would refer to the guide later on, as "it will serve as a useful reference guide for the future".

All participants reported that they had fulfilled their commitment to use Word to produce at least one assignment or substantial piece of written mathematics, with 13 having produced more than the commitment. Moreover, the overwhelming majority of students used both methods of input in Word: typed input and palettes. This meant that their evaluations of Word were based not just on cursory experimentation, but rather on serious engagement with the software. 10 had used Word 2007 for at least one assignment, with a further 2 having used Word for some of one or more assignments. However, half had not used Word for an assignment (but had trialled it for other documents).

#### 4.2 Student perceptions of Word for mathematical typesetting

In general, students appeared to be supportive of Word as a tool for inputting and editing mathematics (see Figure 1). In fact, 15 rated Word as either good or very good for mathematical input, with only 5 rating it as poor or very poor. The results for editing already typed mathematical content were less favourable, as participants identified editing as being a weakness of Word. While 13 rated Word as good for mathematical editing, nobody thought Word was very good in this category. In fact, 6 rated the editing feature in Word as poor or very poor. This may be due to one of several reasons. When editing an expression using the graphical approach, it can be difficult to position the editor cursor at the exact point of the two-dimensional notational structure required to make the edit. Alternatively, whilst the typed interface uses LaTeX-like commands such as “`\matrix`” for input, this is quickly automatically replaced by default with a solid black-box glyph. Other commands are similarly replaced by the same glyph making the linear syntax difficult to read whilst editing.

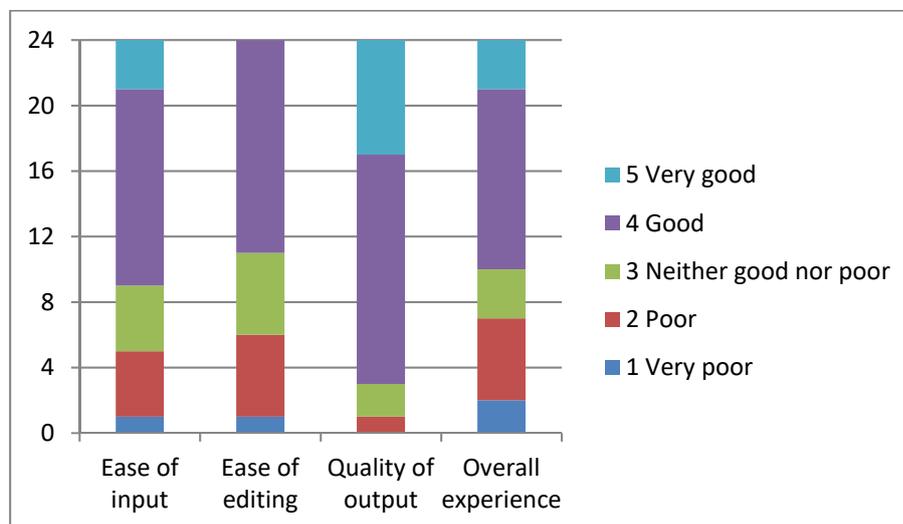


Figure 1 Participant evaluation of Word. Each aspect was evaluated on a five point Likert scale with (1 = very poor, 2 = poor, 3 = neither good nor poor, 4 = good, 5 = very good).

In terms of quality of output, there is overwhelming support for Word, with 21 giving it a good or very good rating. On the other hand, nobody rated Word as very poor, and only 1 gave a poor evaluation. We note that this is in contrast to anecdotal wide-spread beliefs that Word does not produce high quality mathematical typesetting!

To establish the quality of the mathematical content the students were typing in their assignments, students were asked if they had typed as many mathematical equations and in as much detail, in Word, as they would have done using pen and paper or any other software system. One student commented “Yes, I made Word produce the output I wanted, and did not compromise on the maths notation.” Another student said since he writes “all mathematical input on paper before transcribing into Word (or LaTeX)”, Word assignment authoring did not result in different assignment content.

A major consideration in all mathematical typesetting is the time required to enter mathematical expressions, and it appears that Word is no different. No participant rated Word as very fast, although 7 gave it a fast rating. On the other hand, the same number (7) gave a slow rating and 2 a very slow rating, with 8 rating the software as “neither fast nor slow”. Open ended comments show the split views: “However the ability to produce high quality typeset mathematics in a reasonable time is very useful.” This student also said that pen and paper would always be the easiest form to

write mathematics. Another commented that “I would write more equations with pen and paper simply because I am not used typing maths and find it quite time consuming.”

There was also the view that while it took longer to type up an assignment at this stage and the student “wouldn’t type as much maths as when using pen and paper”, this student hoped that with more experience this would become faster. Others hoped that with more practice they would become faster and would be able to “take short cuts.”

When asked to comment if they had experienced any technical issues, one third of students reported that they had. Issues raised included equation numbering and bringing up the ribbon menu for an already-typed equation. These problems relate to the level of proficiency the students had reached in the use of Word.

Students were then asked to integrate their separate experiences to provide an overall experience score. 14 of the participants rated Word as good or very good, compared to 7 who rated the software as poor or very poor. Issues raised by students include slow initial start-up, the obscuring of mathematical text by the equation box, problems with editing (some formulae had to be ‘started from scratch’), line numbering, alignment of equations, cross-referencing and occasional file corruption. Matrices and polynomials were remarked on as being particularly hard to handle. However, our impression that the new equation editor available since Word 2007 is much improved in terms of usability and quality of output was confirmed by students who had used previous versions, as this comment shows: “I had abandoned using the previous Word editor. Word [2007] is very much better in all respects.”

#### *Students’ comparison of mathematical typesetting solutions*

Since participants had experience with various mathematical typesetting solutions, we were able to compare their preferences for Word with alternative tools, see Table 2 for results. A strong preference for Word was expressed by those who had used earlier versions of Word together with equation editor, and by those who had used OpenOffice (<http://www.openoffice.org/>). A student who had been using MathType in the past thought that Word would be “OK for the inexperienced or occasional user, but is frustratingly cumbersome for the experienced user [of other systems]”.

Since most students had only used LaTeX or Word, we will now focus this discussion on the comparison of these two tools. Previous LaTeX users were split between those who preferred Word (8) and those who preferred LaTeX (12), with the rest expressing no preference. In their comments, a small number of students with LaTeX expertise didn’t see the need for another tool and thought Word was “too much hassle”.

**Table 2 Preferences for Word over an alternative software package**

Alternative software package	Prefers Word	No preference	Prefers alternative	Total number who used the alternative
Earlier version of Word & Equation editor	14	0	2	16
Earlier version of Word & Mathtype	3	2	2	7
OpenOffice	4	2	0	6
LaTeX	4	2	6	12
Other	1	0	0	0

It was interesting to see that, in general, students who are using LaTeX (although we have no information about their level of proficiency) commented that they preferred LaTeX, as they had already invested in the learning process and because they appreciated the high quality of the output generated in LaTeX. The fact that in LaTeX coding can happen entirely with the keyboard and without the use of the mouse was seen as an advantage for LaTeX. In addition, it was seen as

slowing down the process when the palette is used for Word, as reflected in this student comment: "LaTeX is much easier because when you've learned the code, you can type quickly, but with Word 2007, you have to keep using the mouse which makes things slow". In contrast, another student commented that once you know the keyboard shortcuts in Word, it is faster than LaTeX. It appears that personal preferences play a role, as the following comment confirms: "I found the balance of markup input (a la LaTeX) and mouse input was very good [in Word]".

Other student comments related to the immediacy of seeing the mathematical typesetting. A student who prefers LaTeX pointed out that "Word is much more visual than LaTeX, but LaTeX is much faster once you are used to it." This "ability to see the output 'as you go'" was viewed as helpful by another student. However, editing already typed mathematical formulas was more difficult in Word than in LaTeX: "often deleting far more than intended when using backspace, for example - very frustrating". The same student, on the other hand, liked that aligning equations was quicker in Word than in LaTeX. Nevertheless, he still preferred LaTeX to Word for its more professional output.

There also seemed to be the view that both LaTeX and Word are useful for typesetting mathematical documents and should be used in combination: "For the purely mathematical input, LaTeX works a bit better. For the overall document, especially with graphical input, Word is easier. I like the way that I can use Word normally, and add mathematical material as needed."

As we have seen, students appeared to generally think favourably of Word for mathematics entry. Several students said they were impressed, "I was very impressed, I wrote my 80 page Master's Dissertation using it, not having used it before, and I quickly got into it. I was used to Word 97, so using 2007 was a major change, with its new ribbon structure." Another said it was not difficult to learn to use it as a relative novice and that he "quickly felt comfortable with it" and would use it for his next assignment. He also said that he "would not have dreamt [he] would have done so before this experiment". We also received the comment "I found that it is doable - anything else I had tried is not. I produced a fine TMA [Tutor-Marked Assignment] and my tutor was complimentary about the presentation". The following student summarised what many may have been thinking:

"I feel that I don't have to learn LaTeX because I am satisfied with Word 07."

There was, however, also one concern raised regarding the fact that electronic assignment authoring may replace handwritten mathematical working, with a student commenting that he was concerned that he "will not have the practice of handwriting solutions - which is necessary for the exams."

Finally, we asked the participants whether they would use Word for mathematical typesetting in the future. The majority (14) intended to use Word for mathematics either frequently or very frequently in the future, with 4 rarely or never, while 6 of the participants intended to use Word occasionally. For authoring assignments, 11 would use Word frequently or very frequently, while 7 would use the software either rarely or never.

## **5. Discussion and conclusion**

Although professional mathematical typesetting is common amongst mathematicians and mathematics educators in higher education, student engagement has lagged substantially behind that of their lecturers. We suggest several reasons for this lack of engagement.

First, the higher education mathematics curriculum is already overloaded and educators have been reluctant to release credits, even as part of a wider employability and generic skills agenda. Second, some educators believe teaching mathematical typesetting would give an overemphasis to form over content and, indeed, might even detract from mathematics learning, especially when one takes into account the time taken to acquire and to use the necessary skills. Third, there has been a fear

that the widespread use of mathematical typesetting by students, especially in the preparation of their assignments, would necessarily result in the loss of intermediate steps in calculations, thereby making it harder for educators to diagnose mistakes. Fourth, there has been a reluctance to teach skills which students will not be able to use in examinations and which may not be of great utility in their future lives, except when needed for the production of dissertations or project reports. Finally, the quality of mathematics output in standard word-processing programs such as Microsoft Word has in the past not been comparable with that produced from LaTeX, which has added to the reluctance to include mathematical typesetting other than LaTeX in the curriculum. We note that since this study was conducted, tools such as the web-based instant rendering WriteLaTeX have emerged, which may be well worth investigating as an alternative in a future study.

Have the new mathematical typesetting capabilities of Word alleviated the concerns highlighted above? We believe so, as at least MSc students were positively surprised by Word's mathematical features and commented favourably, in particular with regard to quality of output and ease of input, although doubts still remain about the editing of mathematical expressions. The results show that the current versions of Word are indeed capable of producing quality mathematical typesetting, that the learning curve is not steep, and that Word cannot be dismissed as a tool for students to typeset their mathematical assignments. Although there were concerns that editing takes longer in Word than in other tools and that typesetting in general takes time, student impressions were positive.

Recalling the principal research questions that we posed above, our results suggest that Word may indeed be a suitable tool for students to typeset mathematical assignments, although students may well need some training in order for them to make best use of the package. Certainly, many of the students who were introduced to Word will continue to use it in their studies, to a greater or lesser degree. With regard to our second question, it is clear that Word does compare favourably with other mathematical typesetting packages students have used, especially compared with earlier versions of Word and embedded packages, and, at least in some students' experience, with LaTeX.

Of course, the wider educational questions proposed above remain largely unanswered by our study, although many concerns about the use of mathematical typesetting would dissipate if the speed of mathematical typesetting were to be significantly enhanced. However, we are far off from the mathematical handwriting recognition necessary for such an advance although there are research projects in the field, e.g. MathPen (Lo et al., 2013), to convert handwriting into typeset text and mathematics.

One future direction for research follows on from a comment raised by a student, which appears to imply that this student no longer writes mathematics on paper. It would be of considerable interest to discover whether students indeed do reduce the amount of handwriting while working through a mathematical problem, as this could have serious consequences on the amount of deep learning that occurs during practice, by "doing" the maths by writing it out. This is of particular importance when considering the still common paper-based end-of-semester exams as they may be the first major assessment item that requires students to write complete mathematical explanations by hand.

We note that our results are not meant to convince a mathematician to change from LaTeX to Word, but hope that they will encourage educators to consider Word as an alternative for student use. We also acknowledge that this case study provided insight into the perceptions of only one cohort of Master level students. Further research is needed in this area, with larger participation groups, before generalisations can be made.

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