MATHEMATICS ON ONENOTE

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Microsoft OneNote is a program that has great benefits for students and teachers of mathematics. It helps organise mathematics notes for a class and for individual students. Using OneNote, mathematics can be handwritten on a tablet computer. OneNote can be used for learning and teaching mathematics online. Potentially, OneNote provides a mechanism which allows the teacher to adapt learning materials to suit the cognitive needs of individual students.

Mathematics on OneNote

Microsoft OneNote is a note-taking program that allows the user to collate information in a variety of forms including text, images, spreadsheets, audio commentaries and videos. OneNote provides a structure for the organization of notes and it supports multi-user collaboration. OneNote is also suitable for taking handwritten notes on devices that are operable with a stylus. These features make OneNote practical and beneficial for use in mathematics education.

OneNote provides an organisational structure

OneNote supports learning organization by providing a structure consisting of sections, pages and sub-pages as illustrated in Figure 1 below.

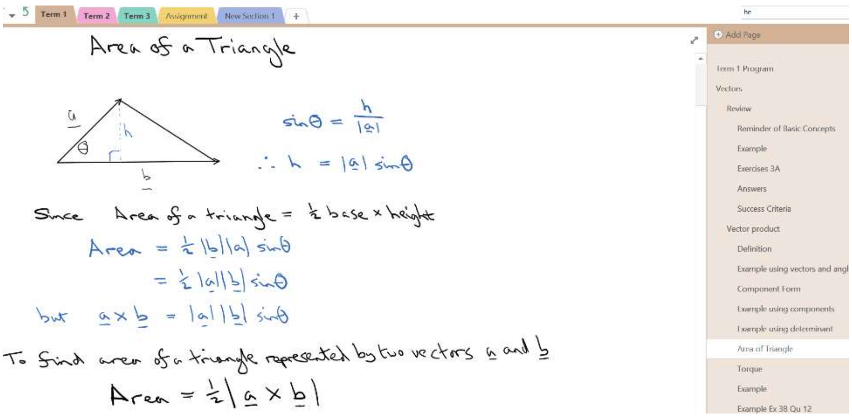

Figure 1. OneNote provides an organized structure.

The organisational power of OneNote has been elevated even further through the development of the OneNote Class Notebook application. This application, has expanded the functionality of OneNote by providing three spaces to work in. The first is a Collaboration Space in which students can input together at the same time. This allows students to collaborate and give one another feedback. The second space is the Content Library. This space is controlled by the teacher and students have read only access to it. In the third space, each student has a notebook of their own with sections and pages. The individual student controls and organises their own notebook. No-one else has access to it apart from the teacher. This arrangement encourages the students to be self-regulated learners, an important skill for the 21st century (Microsoft Partners in Learning, 2012), and makes it easier for the teacher to give differentiated support and feedback.

OneNote provides a natural interface

Mathematics is a language. It has its own syntax, grammar and vocabulary. It is therefore a language in its own right, and not just an extended version of an existing language (Krussel, 1998). The language of mathematics is represented by a diverse array of symbols, diagrams, and characters borrowed from other languages. This brings many challenges to the process of communicating in mathematics in digital form. As far as text is concerned, the use of a keyboard, arguably, has the advantage of speed, leaving more time for thinking (Chemmin, 2014). However, whilst it is relatively easy to communicate with text using a keyboard, some more sophisticated tools are required to support digital communication in mathematical language (Charles & Gaill, 2011).

Instead of trying to communicate in mathematical language with a keyboard, a simple alternative would be to use pen and paper. Another alternative is to use a digital pen (stylus) and write on the computer screen. Research into students' work on hypothesis-generating tasks has revealed differences in communicative fluency according to the type of interface that the students used (Oviatt, 2013). The use of a computer keyboard was found to elevate linguistic fluency, whereas non digital pen and paper elevated non-linguistic fluency (sketching, diagramming and annotating). The use of a digital pen interface was found to elevate non-linguistic fluency even more than non-digital pen and paper tools. These results were replicated in problem solving tasks, strengthening the finding that people communicate more non-linguistic content when using a digital pen interface such as a stylus on a tablet computer. Further, it was found that keyboard-induced linguistic fluency actually suppresses the generation of ideas, whereas the use of a digital pen interface increases the generation of ideas (Oviatt, 2013). In relation to hypothesis generation and problem solving – important skills in STEM disciplines – it appears that the pen is mightier than the keyboard, but, in turn, the stylus is mightier than the pen.

Using OneNote with a stylus on a tablet computer helps students deal with the intricacies of mathematical language by simply handwriting it rather than having to depress a complex sequence of keys. It also affords the user the ability to gesture, annotate and diagram, thereby supporting non-linguistic thinking. An example of non-linguistic thinking communicated through the use of OneNote with a stylus on a tablet computer is shown below.

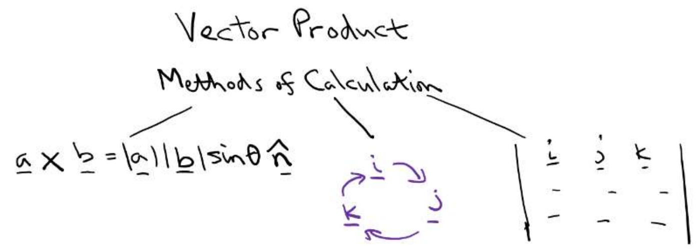

Figure 2. Non-linguistic thinking on OneNote.

OneNote can be used for online learning

Mathematics courses can be delivered online effectively using a blend of synchronous and asynchronous methods. Some of the learning takes place with the teacher and students communicating together online at the same time, and other learning is supported by resources made available over the internet. In conjunction with other software, OneNote can be used to support both the synchronous and the asynchronous components of online learning.

In 2014, a class of Year 11 students from Ormiston College in Brisbane Australia were enrolled in a Year 12 course in Probability and Statistics. The students completed the course entirely online, and then sat the examinations at school under supervised conditions, and in accordance with the assessment criteria of the Queensland Curriculum Assessment Authorities. OneNote was used in the synchronous and asynchronous aspects of the course. The use of OneNote online is depicted below. Using the show desktop feature of the software Skype for Business, online lessons were conducted in which OneNote was used to handwrite mathematics on a tablet screen. OneNote was also used in screencast recordings made with an add-in feature of PowerPoint called Office Mix. In the recordings of these examples, OneNote is an integral part of a multimodal experience which is spontaneous, visual and has a friendly human voice.

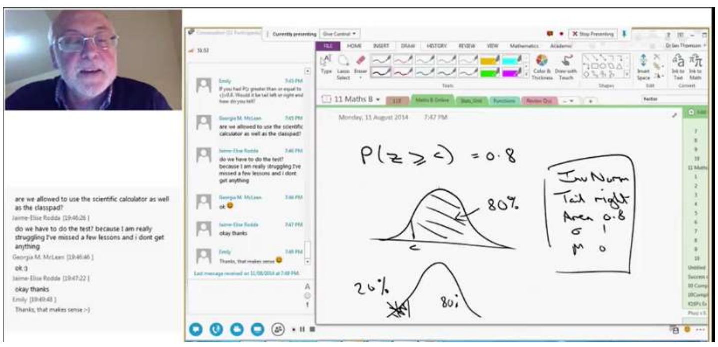

Figure 3. Using OneNote for online learning.

Matching materials to the cognitive needs of individual students

When students are learning mathematics they rely on their working memory to cope with new information. This places a burden on their thinking. This burden is known as *cognitive load*. Cognitive load exists in three forms (de Jong, 2010). First, *intrinsic* cognitive load is that associated with the actual subject matter in hand. Second, *extraneous* cognitive load is caused by information in the instructional material that is not relevant to the learning. Third, *germane* cognitive load arises in the construction of new mental schema, and is typified by learning processes such as interpreting, inferring, exemplifying and organising. Each of the three types of cognitive load- intrinsic, extraneous and germane - have unique features. These features may be examined in more detail, in order to identify ways that technology, in this case OneNote, may possibly provide support associated with each type.

Intrinsic cognitive load is to a large extent dependent on the subject matter, which in the subject of mathematics may be, for example, right-angled trigonometry, simultaneous equations or statistics. Intrinsic cognitive load is also affected, however, by the prior knowledge of the student. According to their learning backgrounds, some students will experience higher intrinsic cognitive loads than others.

Extraneous cognitive load comes from aspects of the instructional material that do not contribute to knowledge construction. The classification of cognitive load as extraneous may be dependent on the prior knowledge of the student. Some materials may be necessary for students with limited prior knowledge of a topic, whereas other students may find this same material to be unnecessary, and therefore extraneous. For the latter group of students, the nature of the extraneous material may result in a learning reversal effect (Kalyuga et al., 2010). They find themselves unable to avoid the distraction of the aspects of the material that, to them, are extraneous. This results in an inefficient use of their working memory, and actually retards their learning.

Germane cognitive load can be associated with the complex reasoning processes that students employ when extending their knowledge. It relates to ways of thinking such as classifying, abstracting, induction, deduction and constructing support (Marzano, 2007). Unlike extraneous cognitive load, germane cognitive load is desirable and necessary. It stimulates the thinking processes and promotes the generation of new mental schema. As with other aspects of cognitive load, however, the distinction between extraneous and germane cognitive load is influenced by the background of the student. When acquiring knowledge, for example, it may be helpful to have multiple representations of a new concept. To one student, a graphical representation of an algebraic concept may be germane because the student constructs new knowledge by thinking though the connection between one representation and the other. To another student with more prior knowledge, however, the graphical representation may be superfluous and, to them, extraneous.

The OneNote Class Notebook, as described earlier, allows each student to access a common library of content whilst at the same time having an individual private section which they control and to which no one else has access apart from the teacher. This means that the student can customise the content, and thereby attune the intrinsic cognitive load according to their individual needs. The teacher can also assist in matching the intrinsic cognitive load to the needs of the individual student by adding or cutting information in the student section. This provides a mechanism which allows cognitive load to be classified as intrinsic or extraneous relative to the individual student rather than on a “one size fits all” premise. In a similar way, the classification of cognitive load as being germane rather than extraneous can be made in relation to the student, and materials can be customised accordingly.

“Back to the Future” of handwriting mathematics

Cognitive load can be affected by the type of computer interface that the students use. Research by Oviatt et al. (2006) which compared the effects of different types of educational interfaces found that students’ performance on mathematics word problems was constricted by the use of a keyboard. The use of a keyboard to produce mathematical notation induces extraneous cognitive load that would not be experienced when writing in a natural way by hand. Pen and paper would be less problematic in this regard. A tablet computer with a stylus, however, offers an alternative that takes us “Back to the Future” of handwriting mathematics. Writing mathematics by hand on a tablet computer avoids the extraneous cognitive load associated with a keyboard. It has the advantage, however, of producing a digital artefact which, although handwritten, may be stored, copied, transmitted, edited and annotated. The fact that OneNote facilitates writing by hand on the computer screen is arguably the most significant benefit of OneNote in relation to mathematics education since it combines the benefits of a natural interface with a digital product.

Benefits of sound and vision

There are instructional benefits to be accrued when a teacher models a think-aloud process when working through the reasoning of a problem. The students cope better when the explanation and the visualisation are presented in different modalities (Marzano, 2007). This modality principle also applies in the context of multimedia presentations, where it is found that an auditory explanation accompanying a visual description is more manageable than having both the explanation and the description in a visual format (De Oliveira et al., 2015) In other words, the combination of sound and vision has a lighter extraneous cognitive load than the purely visual combination of text and diagrams.

The combination of auditory and visual presentation is achievable using OneNote. This facility was utilised in the example of online learning described earlier. The students could experience this in a synchronous way (students and teacher online at the same time) and in an asynchronous way (students watching a recording of the presentation). Either way the extraneous cognitive load was mitigated by the combination of auditory and visual explanations.

Summary

OneNote is a note-taking application that is very suitable for use in mathematics education. If offers an interface between students and computers that supports the organisation of their learning. OneNote can be used to make handwritten notes on a tablet computer using a stylus. This helps the students cope with mathematical notation in a digital environment, since it is easier for them to handwrite rather than type the details. It also elevates non-linguistic thinking which improves problem solving. The OneNote Class Notebook application has a collaboration space, a content library and individual notebooks for each student. This supports multi-user collaboration, self-regulated learning on the part of the individual student, and differentiated support for the class from the teacher. OneNote can also be used effectively to deliver online mathematics courses using a blend of synchronous and asynchronous methods. Potentially, OneNote provides a mechanism which facilitates the fine-tuning of intrinsic, extraneous and germane cognitive loads on students' working memory.

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