Digital Interfaces for Learning

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In the last few years there has been considerable research into the use of notebooks, tablet PCs and other mobile devices in education, and there is the perception that:

> *"the majority of studies in this area are about teachers using computers in instruction and there are fewer studies about students using them in learning. That is, often the studies compare teaching in classes with and without computers (of some variant) rather than comparing students learning in different ways when using computers (Crook et al 2013 quoting Hattie 2009 p. 221)."*

This was certainly the case until recently and whilst they still constitute the majority of the research, there have now also been papers published that look at the quality of learning rather than the teaching. Specifically, research has looked at student learning when notes are typed rather than handwritten. Initially this research compared the use of pen and paper against typing on a notebook, but more recently the frames of reference have broadened to include using touch, using gestures, using a digital pen (stylus) on a tablet, using a digital pen with digital paper and using a keyboard to type.

Professor Iain Davidson, Emeritus Professor of Archaeology in the School of Humanities at the University of New England, Armidale NSW has written on the impact of digital communication in cognition and cognitive evolution and said :

> *"The ongoing impact of instantaneous communication provided by the penetration of electronic devices (such as mobile phones) into all aspects of human life makes it highly likely that we are in the midst of further subtle cognitive changes." (Davidson 2010 p. 224)*

One only has to look at our youngest children who navigate digital devices long before they are able to read and write to gain a sense of these changes. These children are growing up in a world that revolves around touch technology. At the upper end of the school we see examples of the different ways our boys use devices. Today's Year 12 student demonstrate some discomfort when asked to use a pen on a digital device, but the younger students are seemingly more comfortable with this technology. Anecdotally we see the level of use of pen technology as correlating inversely to the age of the student. An increase in the take up of touch and pen technology would, therefore, be expected in the senior secondary years as the current primary and middle year students progress through their schooling.

When deciding on the best device for students to use in an educational setting there is clearly much more to consider than the cosmetic. In all assessments the critical issue needs to be the enhancement of learning. Just because we can use a computer does not necessarily mean we should use a computer, but when use of a computer is appropriate, it needs to be fit for purpose.

We often hear that no one device fits all purposes and this is true. What schools need to try and do, therefore, is select a device that best serves the majority of needs. To do this, we need to consider how computers are used in classes today, how the technologies are developing, what impact that is having on the way children and adolescents learn and what would be possible if we were to embrace the new technologies.

When the iPad was first introduced there was a sense that this was the device that would revolutionise education, and perhaps it has. The iPad and other tablets that have followed have possibly provided the basis for the change in cognitive patterns to which Davidson was referring. As students mature they are required to perform a greater range of tasks, some quite specialised, and a survey of these students revealed that "tablets were the second or third choice device for completing many of the academic tasks" with which they are faced (Reidel, C 2014). This does not mean that the students do not see the importance of the tablet, just that they see the need to have different ways to input data. Students value the role of the tablet with its touch interface, but with the absence of a keyboard and/or mouse, recognise that it cannot yet replace a computer in all circumstances.

The rise in use of video and other modes of communication also contribute to the discussion. Terms like blended learning and flipped classes are testament to this. Tablets and mobile phones are excellent devices for playing video (content consumption) and the ability to use them for video editing (content creation) has certainly improved in recent time. It is true, however, that the computer is still the better device for high level content creation. This no doubt leads to the proposition that the Macintosh is superior to Windows in this area. Many schools continue to offer a dedicated suite of Macintosh computers for use in the music and multi-media areas, largely because of this perception, but we must also acknowledge there is strong evidence that this gap is closing. Importantly, we need to consider whether or not a device with only one mode of input and which might well excel in one area is the appropriate device for students who in the course of any one day, will engage in a broad array of learning tasks. This is addressed later in this paper.

Mueller and Oppenheimer (2014) found from three studies that "students who took notes on laptops performed worse on conceptual questions than students who took notes longhand." They also found that "laptop note takers' tendency to transcribe lectures verbatim rather than processing information and reframing it in their own words is detrimental to learning."

In short, Mueller and Oppenheimer concluded that "taking notes with a pen and paper, rather than a laptop, leads to higher quality learning, as writing is a better strategy to store and internalize ideas in the long haul." Other educational psychologists have identified the importance of hand activity like writing on learning and memory:

> *"Writing is an immensely important and equally complex and sophisticated human skill commonly ascribed a fundamental role in children's cognitive and language development, and a milestone on the path to literacy." Mangen and Velay (2010)*

So does this mean that students should not use computers? Certainly not, but it does reinforce that we need to use a computer only when it is appropriate and that the decision should always be more about why than it is about how.

The European Commision's Joint Research Centre through the Institute for Prospective Technological Studies commisioned a study involving policy and decision makers, teachers, students, parents, experts in the field of ICT and learning, and e-learning experts. This report, by Aceto et al (2014) 'Mapping and Analysing Prospective Technologies for Learning' endorsed the view that:

> *"a cultural shift is occurring across all sectors of education, reflecting the profound wider societal change being effected by technologies more generally" (p. 44)*

and that :

> *"There is universal agreement about the overall direction of technologies for digital learning across all sectors of education and training, i.e., towards individually owned/used devices - what is now being referred to simply as 'screen technology', smartphone and tablet devices". (P. 35)*

Implicit in the term 'screen technology' is that the device is touch enabled.

Berninger's work (2009) with young children revealed that when primary school aged children writing by pen and by keyboard were compared on alphabet writing, sentence constructing, and text composing, the children who wrote by pen wrote more words and wrote words faster and expressed more ideas. When letter writing and constructing sentences, the keyboard proved better.

Dr Sharon Oviatt (http://www.incaadesigns.org/) is internationally known for her work in human-centered interface design and evaluation, educational interfaces, mobile interfaces, pen, speech, and multimodal interfaces (those accepting at least two of keyboard, speech, gestures, touch and pen). Her most recent publication 'The Design of Future Educational Interfaces' (2013), offers an analysis of available technologies and seeks to give a better understanding of what constitutes an effective educational interface for student cognition and learning.

Oviatt evaluates the suitability of devices that use as their input interface, the keyboard, touch and pen(stylus) or a combination of all three. Like Berninger with young children, what she has reported for older students is that there is a significant cognitive benefit in different forms of input, based on the type of work being undertaken.

Put simply, when the exercise is of a linguistic nature, ie involves extensive writing and the formation of sentences, students expressed 41% more linguistic content when using a keyboard-based interface. That is to say, they formed better sentences and wrote more when typing rather than using a pen.

On the other hand, in a non-linguistic exercise, ie involving diagrams, symbols and numbers, they expressed 56% more nonlinguistic representations which resulted in a 38.5% increase in their ability to produce appropriate ideas when using pen interfaces.

Oviatt concludes that when students use a keyboard-based interface, they experience higher cognitive load that can undermine their performance during STEM tasks (science, technology, engineering, mathematics). During science activities, students who used a keyboard-based graphical interface solved problems more slowly, solved fewer problems correctly, and forgot more problem content, compared with using a digital pen interface. For the same students solving the same science problems, their percentage of correct solutions dropped 10% when using a keyboard-based interface.

During mathematics tasks, a comparison of students' speed, attention, metacognitive control, correctness of solutions, and memory revealed that they performed better when using a digital pen and paper interface than a pen tablet interface, which in turn supported better performance than a keyboard-based graphical interface.

Oviatt (2012) concludes that using a computer can motivate and engage people more than non-digital tools, can increase their communicative fluency and can facilitate related cognition. At the same time, however, she makes it clear that a computer can, if the wrong interface modality is selected, significantly impede learning and understanding.

These findings emphasise why multimodal interfaces are a promising direction for future educational interfaces.

Oviatt (2013) concludes that "As digital tools for education, multimodal interfaces offer significant performance advantages over unimodal ones, especially when a user is mobile or working on a difficult task." and somewhat alarmingly, "keyboard-based graphical interfaces provide an impoverished tool for problem solving and learning activities."

Table 7.3 in Oviatt's book lists reasons why multimodal interface tools are well suited for stimulating conceptual change.

It states that multimodal interfaces:

- Support natural interpersonal communication patterns, such as speaking and writing
- Leverage evolved multisensory brain processing abilities
- Stimulate higher levels of communicative activity than unimodal or graphical interfaces
- Improve accuracy and stability of communicative intelligibility, by avoiding and resolving miscommunications more easily
- Improve efficiency of communications (ie simplicity, reduced length, speed)
- Improve accessibility of computing for diverse users (eg with sensory or cognitive impairment)
- Improve usability of computing in field and mobile contexts, and in different environmental conditions (eg noise, darkness)
- Support preferred communications pattern when working on difficult tasks
- Support flexible communication, including alternating or combining modes (eg alternating interpersonal dialogue/writing during multi-phase or collaborative problem solving)
- Support socially situated communication that facilitates efficient distribution of information across people during collaboration
- Support improved robustness of memory, due to dual coding of information
- Support reduction of cognitive load and self-managed of cognitive load during changes in tasks and other situations
- Support greater expressive power, which mediates the ability to produce ideas and explore possible meanings through communicative activity
- Inherit features and advantages of their component modes (eg pen input accurately conveys spatial information)

Oviatt (2012) says that "perhaps surprisingly, people have very poor intuitions about the impact of computer interfaces on their own performance." Specifically, Oviatt's studies found that when presented with the ability to use either pen or keyboard, 65% of student input was via the keyboard, even when it meant that achievement would be lower than optimal. We can conclude from this that even though teenagers may be experienced users of computer interfaces, they do not necessarily have accurate self awareness or judgment regarding how to use them to best advantage.

Galatis and White (2013) state "It is not a case of learning how to use a device -- one needs to have the skills to adopt and adapt as the situation demands it."

Higgins et al (2012) for the School of Education, Durham University said:

> *"The crucial lesson emerging from the research is that it is the pedagogy underpinning technology use which is important: the how rather than the what. The challenge is to ensure that technology is used to enable and to advance effective teaching and learning practices."*

The role of the teacher in guiding the students re the use of their devices to optimise learning cannot be underestimated. So if we are to use computers in our classes, we should be looking to use them not simply to do better what we have always done, but rather to embrace new theories of learning and with a deeper understanding of how these devices impact on learning. Only then will we be doing justice to our students.

It is essential, but not easy for schools selecting educational interfaces, to accommodate the developmental differences between students of different ages whilst at the same time, considering the usability of different input modalities and their impact on the students' ability to learn. The best we can hope for is to select a device that addresses the majority of considerations at the time.

As the availability of touch-based apps increases exponentially by the day, the most appropriate device at the time of writing would seem to be one which allows for input by keyboard, touch and pen. Such devices provide for the use of single purpose apps, the use of traditional software that uses keyboard and mouse as well as newer software that allows for the use of a pen. The case for each of the three modes of input seems clear, and to omit any one of these would potentially impact negatively on students' learning.

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