New Zealand Annual Review of Education (2020) 26: 43-51
DOI: https://doi.org/10.26686/nzaroe.v26.6857

Software literacy in shaping what we know in a software-saturated society

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Today's modern societies are increasingly dependent on digital technologies and the software underpinning these technologies in almost every sphere of professional and personal life. These technologies and software are poorly understood as tools that shape our engagement with knowledge, culture and society in the 21st century. None of these tools are 'neutral.' They embody social and cultural assumptions about their use and all have particular values embedded in their interfaces and affordances. This paper draws from a funded research project investigating the notion of software literacy (Khoo, Hight, Torrens, & Cowie, 2017). In the project software literacy is defined as the expertise involved in understanding, applying, problem solving and critiquing software when it is used to achieve particular goals. The project team hypothesised there exists three progressive tiers of development towards software literacy in professional contexts. We conducted case studies of engineering and media studies students' learning of an ubiquitous software such as PowerPoint as well as proprietary discipline-specific software to examine how software literacy is understood, developed and applied in a tertiary teaching-learning context. In this contribution we outline the project findings then use the notion of software literacy as the lens to unpack and illustrate through three everyday examples how software literacy would seem to be an essential part of learning and living in the 21st century.

Keywords: software literacy, software application, software platform, affordance, digital literacy, digital technologies

Introduction

Software literacy is the expertise involved in using, problem solving, critiquing and selecting software when it is used to achieve particular goals (Khoo, Hight, Torrens, & Cowie, 2016). This expertise is important given that there is software embedded in the digital technologies we use in nearly all aspects of our daily professional and personal life, from work to leisure. Looking to the future, the World Economic Forum (WEF) *Future of Jobs* report (WEF, 2020) has indicated that 84% of global employers surveyed will look to digitalise their working processes and expand remote working. A third expect to rely on digital tools to create a sense of community, connection and belonging among employees.

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This dependency on digital technologies comes with the need for interrogation into the role of software in shaping knowledge generation, curation and dissemination and communication and connection more generally. Software is not neutral (Manovich, 2013): it comes with social and cultural assumptions that afford particular actions while making others less possible and imaginable. However, the role software plays in shaping our actions tends to be taken for granted (Manovich, 2013). In this paper, we firstly introduce the notion of software literacy and briefly describe how we have examined this notion in a tertiary teaching-learning context through examination of PowerPoint use and case studies of engineering and media studies undergraduate student learning. We then, to support the wider consideration of the role of software in everyday life, employ the notion of software literacy to analyse the way software shapes how we conduct education research, navigate, and access, share and use recipes.

Examining software literacy

Embedded within any digital device, software operates at multiple levels in contemporary life; as applications and platforms which we engage to facilitate and augment a host of social, economic and political practices, and less obviously as part of the taken for granted infrastructure of globalised cultural and economic exchange. The role of software, however, is an often taken for granted aspect of the digital world, which needs to be recognised as a distinctive part of contemporary literacies with its own dynamics and qualities in enabling and constraining other literacies. Many practices within contemporary life, including those aggregated under the umbrella of digital, media and information practices, are now 'coded' in the sense that they only exist and are constituted through programming code (Kitchin & Dodge, 2011). We propose the term 'software literacy' defined as the expertise in understanding, applying, problem solving and critiquing software in pursuit of particular learning goals and professional contexts (Khoo, Hight, Torrens, & Cowie, 2017). We use the term 'literacy' to direct attention to how individuals make use of software and for what purposes, in what contexts and with what anticipated and unexpected outcomes. Our notion of software literacy is grounded in a practice-based framework which aims to identify what distinguishes a novice user from an expert user through proposing a progressive transition from novice to expert-like understanding, capabilities and qualities (Jones, 2008; Livingstone, et al., 2014).

Our project

The *Copy, cut and paste: How does this shape what we know?* research project was a two-year Teaching and Learning Research Initiative (TLRI) funded project (Khoo, Hight, Torrens, & Cowie, 2016, 2017). This examined the notion and role of software literacy in tertiary engineering and media studies. The overarching research question was: To what extent and how does student software literacy develop and impact on the teaching and learning of discipline specific software in formal tertiary teaching settings? In collaboration with an engineering and a media studies lecturer, the research team case studied and investigated how software literacy develops and impacts on the teaching, learning and student understanding, and student use of the practices associated with knowledge generation, communication, critique and use. Multiple forms of data were collected through lecturer interviews, student surveys and focus group interviews, and lecture and lab observations. In the first phase of the project we explored lecturers' and students' software literacy

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understandings and skills about PowerPoint. PowerPoint was selected because it could be expected to provide an inclusive context for analysing the role of software in affording and constraining student opportunities to learn and know. Moreover, the affordances of common actions such as *Copy, cut,* and *paste* are assumed to be naturalised and embedded across different software applications and able to be picked up with ease by this current millennial generation for work and leisure pursuits. However, these affordances are also poorly understood as tools contextualised within larger hierarchies of affordances and interfaces that shape both their use and more broadly people's engagement with knowledge, culture and society in the 21st century (Livingstone, Wijnen, Papaioannou, Costa, & Grandio, 2014).

In the second phase, the research team investigated how discipline-specific software literacy developed in two formal learning environments: engineering and media studies education. Each of these disciplines made use of proprietary software – Final Cut Pro and Adobe Creative Suite (media editing applications) in Media Studies, and Solidworks (a Computer-Aided Design (CAD) software) in Engineering. We were interested in how and if this development fitted with the project's hypothesised three progressive tiers of development for software literacy: 1) a foundation skill level where a learner can use a particular software, 2) which progresses to an ability to independently troubleshoot and problem solve issues when using the software, and, 3) finally, to the ability to critique the software, including being able to analyse software designed for a similar purpose and to incorporate this understanding toward new software learning. This third and ultimate tier involves the ability to identify software affordances and their implications (including the constraints), make informed decisions about selection of software, and identify ways to apply and combine software use such that it is relevant and meaningful to a wider range of learning purposes and contexts (Hight & Khoo, 2021). Users at this level have a sophisticated knowledge and an understanding of a range of software and what is 'useful' for particular kinds of tasks. In the project we used the three tiers as a reference point for thinking through software literacy and its development.

Overview of the findings

Student survey findings (n=179) in phase 1 indicated that students were able to use the three tiers to evaluate their literacy level with 42% stating they had basic skills, 19% that they could troubleshoot, and 29% that they could apply PowerPoint to a range of tasks. Focus group interviews suggested that although students tended to assume that they knew the software in-depth, this was not always the case. There was a good deal of debate over student preferences in relation to the use of PowerPoint with these debates focused more on the style used by lecturers. Discussions were complicated by a general lack of ability to think critically about the ways in which the PowerPoint software might be shaping their learning and teaching, that is, shaping the kinds of knowledge they gained. Of those who analysed the impact of PowerPoint, most comments revolved around the fragmentation of knowledge:

> In PowerPoint, you see a lot of factoids put on the screen rather than actual information. … Society as a whole seems to be heading towards factoid based learning rather than actual learning. … The flip side to that is that people only look at the bullet points and not push their own research [into its use] further, looking into it deeper.

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In relation to student learning about professional software in a tertiary setting (phase 2), the three tiers provided a useful framework for understanding the development of their software skills (Khoo, Hight, Torrens, & Cowie, 2017). However, student progress between the levels was fluid and flexible, dependent on student familiarity with a particular software and the context of use. Students did not need to start from the first tier when encountering a new software if they were already familiar with the software's conceptual/operational framework. Project findings highlighted the value of examining discipline-specific goals for software use. In media studies, lecturers highlight that criticality (tier 3) was an important goal because they viewed it as central to the capacity to develop and express creative ideas. In engineering, the capacity to use the specified software (tier 2) was perceived to be an appropriate end goal. This tier was emphasised on the basis of the specified software's wide use in industry to generate practical engineering designs and ideas. In this way, different disciplinary and curricular goals affected and directed attention (or not) on the way software was taken up and used. Our overall findings suggest that the formal coursework focused on software learning helped to develop students' software literacy so that nearly all students reported a shift to at least tier 1 (basic ability). After completing a course, around half of students across both disciplines felt confident enough with the software that they could either troubleshoot problems, or apply the software to a wide range of tasks, suggesting a literacy level of tiers 2 to 3. This said, across both disciplines few students achieved tier 3's critical awareness of the influence of software in shaping disciplinary knowledge in relation to its impacts on professional ways of working. Triangulation of data sources suggested that these students were in most cases already competent on entry to the course, thereby highlighting the challenge of developing student capacity to critique within the formal opportunities available in a tertiary setting. It raises questions about how institutions balance providing students with both depth and breadth of experience in a limited timeframe. We now turn to consider how software use might be implicated in everyday life.

Considering the implications of software literacy in everyday life

The special issue theme includes a focus on provocation. In response to this we now consider three instances where software use is pervasive, taken for granted and hence the impacts of its affordances and constraints are not always evident or questioned: education research, navigation, and access to, sharing and use of recipes. In each instance, we use the idea that software is not neutral, consistent with a focus on the third tier of development, to highlight the impacts of software use on these activities.

Software literacy and educational research

A number of educational research practices are dependent on digital technologies. Digital voice recorders and cameras are used to generate data in the field; Google Docs and Folders can be used to support collaboration; digital data storage systems can help organise, protect, and archive data; software such as NVivo and SPSS to assist with data analysis, and web-based tools such as Infogram to support data visualisation. In the current Covid-19 pandemic, Zoom (video communication application) has gained prominence as a means of conducting interviews at a distance (Khoo, Hight, Torrens, & Cowie, 2020; Howlett, 2020). Social media platforms such as Facebook and Twitter are also being used by researchers to disseminate findings to outside academia (Cooper, 2014; Schou & Farkas, 2016). As researchers we have given very little attention to the software

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that is central to the functioning of these various technologies because it tends to be *black-boxed*, meaning that the calculations, decisions and processes being performed are essentially hidden from our critical analysis (Roberts, et al., 2013). However, as Beer (2012) pointed out, software not only makes our research processes more efficient, it also makes some decisions for us: Researcher efficiency is promoted but at the expense of some of their agency.

For example, NVivo (a qualitative data analysis software) offers a clearly delineated, finite set of activities, along with a specialised vocabulary that circumscribes the performance of allowable tasks. Concepts such as *codes, nodes, and queries* that belonged to computing science and database theory long before NVivo was developed have been integrated and subsumed as part of NVivo's common user functions. NVivo's software architecture configures and circumscribes "what is relevant and what is not, what needs to be attended to and what not – legitimating particular ways of being whilst simultaneously delegitimizing (or rendering more or less obscure) equally valid alternatives" (Introna, 2011, p.115). In order to use software like NVivo, the researcher must, to some extent, adjust his or her practices to accommodate the structures embedded within its architecture. This said, researcher user agendas and expertise are still required and consequential in software selection, use and analytical processes. We anticipate that with greater penetration of software into education research, researchers will need to become more critically aware of how software might shift and reconfigure their modes of knowing, thinking and doing.

Software literacy and navigation using Google Maps

In an example closer to the everyday, the advent of location-based software services such as Google Maps has changed the way we plan for and navigate journeys. We are less likely today than in earlier times to work out how to navigate for ourselves and/or seek advice from someone who knows the area. Typically we rely on the software to estimate the time needed for our journey and to guide us along the optimal route. However, with Google Maps our location is by default always at the centre of the map meaning our appreciation of scale and where we are in relation to the whole may fade. Cultural geographers have long argued that maps and the practice of map making play a key role in place-making and our sense of place (Duggan, 2017). They propose lines on a map, numbers, symbols, coordinates, even the limits/edges of a map all contribute to our sense of scale, location and spatiality: We acquire and accumulate our knowledge of place, in part, by working with the malleability of graphical maps. McKinlay (2016) cautions we may lose our innate capabilities for navigation and our spatial memory as well as what we know about the geography of places and their connections if we rely too much on smart devices. These findings raise the question: What are we missing out from having our journeys planned and mapped out for us? What knowledge and skills are valued, what is being lost and what is being reshaped or is newly emerged if we rely on navigational software?

Software literacy and recipe collation, access and use

Moving closer to the home front, software is even impinging on what we cook and eat. Traditionally, recipes have been recorded in a recipe book. They have been shared and passed through the generations scribbled on bits of available paper. The collation of recipes that are shared over time within families constitutes a significant material and cultural practice (Davis et al., 2014). Today, however, it is possible to Google to find the

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recipe of the dish we want to make and be guided in the process by 'how-to' videos. There are many thousands of food or cooking blogs, online recipe sharing forums, and online recipe social networking sites such as KeepRecipes.com. These websites offer users access to virtual recipe collation boxes, the capacity to rate recipes, and create shopping lists. Some websites can suggest recipes based on available ingredients, allergies and others can calculate calories and nutritional value. As attractive and convenient as digital recipe collation options and menu planning might be, the software underpinning their functioning requires users to subscribe to and adjust to the logic of their design. Their use can mean we miss out on the social and often intergenerational interactions involved in the generation of traditional cookbooks (Davis et al., 2014). On the other hand, online blogs are expanding opportunities for amateur cooks to share recipes and become part of a community of home cooks (Dalton et al., 2014). Dolejšová et al. (2018) argues the need to consider which stakeholders are involved and who is excluded from digitally-based food practices. They question the extent that digital technology (and software) support sustainable food practices. Together these studies pose a challenge to the uncritical embracing of software to inform and guide both food production and recipe selection and preparation practices at the family, local, and even global levels.

Conclusion

Claxton (1998) notes that "we are fashioned by our tools and none more so than the computer. For the computer redefines people as 'information processors' and nature itself as information to be processed" (p. 206). We concur but recommend direct attention to the role of software as an actant in (re)shaping all areas of modern life. Software literacy would seem to be an essential part of learning and living in the 21st century as a set of literacies that transcends the use of any particular tool and any particular educational, social and cultural context. Software is not neutral: It plays a role in shifting and reconfiguring many of our existing practices, as well as generating new practices. We have seen this increasingly occurring as educational institutions and workplaces move to use tools such as PowerPoint and Google Docs as well as discipline specific software. More generally, organisations and individuals are exploiting the potential of e-learning platforms, making use of social media, cloud-based and mobile applications, accessing augmented and virtual reality, and using 'Big Data' in decision-making. It is therefore both desirable and advantageous that graduates have a critical understanding of software so they can make more informed and critical uses of the software they employ as part of their professional life and also of that they have yet to encounter. We propose the term 'software literacy,' defined as the expertise in understanding, applying, problem solving and critiquing software in pursuit of particular goals, is essential for everyone in our software-saturated society. We offered three examples – educational research practices, navigation, and recipe collation – as illustrations of the impact of software on social practices. We hope these examples will prompt readers to consider more widely what the software they use makes (more) possible and what it does not.

Acknowledgement

The authors gratefully acknowledge funding support from the Teaching and Learning Research Initiative, New Zealand Council for Educational Research, Wellington, New Zealand.

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