Paper Title: Digital Fluency and the Entitlement Curriculum: Who are the computational thinkers?

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Submission

The concept of a digital curriculum has been discussed widely both nationally and internationally in recent years. In New Zealand, the 2017 Digital Curriculum (Hangarau Matihiko) outlined a vision for two technology areas that provide both an entitlement curriculum (to which every student should be entitled) and a specialist curriculum (for elective study) in computational thinking and digital outcomes. In this paper, we explore the broad set of definitions of digital fluency and ask to what extent this concept is embedded in the digital curriculum. We also raise some questions around the nature of an entitlement curriculum in this area, and to what extent the concept of digital fluency is or is not embodied in that part of the published curriculum that is intended for all students, in contrast to the specialist curriculum that only some senior students will choose to follow. We suggest some important characteristics that should be present in an entitlement curriculum for digital fluency, and discuss some aspects of these that we are

currently integrating into our own courses that address the new curriculum, providing some suggestions for how others might implement the digital curriculum in their own contexts.

Introduction: Curriculum and Change

Curricula do not arise in a vacuum and are not socially neutral, but come laden with sets of values and assumptions, such as whether learning in school is in some way significantly different to learning in the world outside (Unwin & Yandell, 2016). The first schools had a curriculum based on training a suitable number of citizens to be able to create and use clay accounting tablets in the service of the city state (Mlodinow, 2016). In many ways, educational curricula remain grounded in a similar set of functional literacies. This is particularly the case when dealing with STEM subjects such as digital technology where a technical skill set is required in order to deliver assessable outcomes. However, a 21st century education is likely to require something more than a basic technical skill set.

Changes to curricula are driven by a range of forces. These include changes in generational characteristics, society, physical teaching spaces, infrastructure and pedagogy. The New Zealand education system has been slowly adapting to these trends. While the most obvious manifestation of these changes has been the visibility of digital devices in the classroom, the whole process of introducing digital teaching and learning relies heavily on communications infrastructure. One of the most significant changes to this infrastructure in New Zealand education in recent years has been the provision of Ultra Fast Broadband to schools (MoE, 2017a). Building on these contextual changes there is now a move to start embedding digital technologies, skills and competencies at all levels of schooling through changes to the technology curriculum.

The Digital Curriculum - Entitlement and Specialisation

At the end of 2017, the Digital Curriculum (Hangarau Matikiho) was incorporated into the Technology strand of the New Zealand Curriculum, and is due for implementation by 2020 (MoE, 2017b). The rationale provided by the MoE (n.d.a) is to "ensure that all learners have the opportunity to become digitally capable individuals".

The original draft of the curriculum began with the statement from the then Minister of Education that "The new curriculum has the potential to be the ultrafast broadband of learning" (MoE, 2017b). Given the potential for transformation in teaching and learning that broadband access in schools has provided, this was a bold claim. Perhaps the most important aspect of the new digital curriculum is that it is explicit about the components of the entitlement curriculum, i.e. the knowledge and skills to which all students are to have access (Unwin & Yandl, 2016). This contrasts with the specialisation components of the curriculum that are only for some students; those who specialise in technology subjects in years 11-13. The split between the entitlement and the specialist curriculum is at year 10. The curriculum states that by the end of Year 10, all learners should be digitally capable, making them able to apply their understanding of digital technologies to all aspects of their lives and careers. In contrast, only learners who study digital technologies through to Year 13 will be on the pathway to specialising. The assumption is that it is these students who will be able to lead the next generation of innovators and trailblazers in the digital world. (MoE, 2017b).

Technology areas in the digital curriculum

Both phases of the new curriculum are incorporated into two new technology areas; Computational Thinking for Digital Technologies, and Designing and Developing Digital Outcomes. The computational thinking area focuses mostly on computer science principles and aspects of coding, whereas the digital outcomes pathway focuses more on the human aspects of digital systems, creating digital content and learning about the components and design of digital devices. The entitlement curriculum straddles both of these technology themes. Table 1 provides a brief summary of the key aspects of these two technology areas in both the entitlement and the specialisation curriculum.

Table 1: New curriculum technology areas

Entitlement to year 10	Specialisation to year 13
Computational Thinking for Digital Technologies	
• Independently decompose problems into an algorithm that a computing device can understand • Implement the algorithm by creating a program • Determine when to use different types of control structures • Explain and document programs and use an organised approach for testing and debugging • Understand how computers store more complex types of data using binary digits • Develop programs considering human-computer interaction heuristics	• Analyse a selection of areas of computer science e.g. formal languages, network protocols, complexity and tractability, AI, graphics and visual computing, big data, and social algorithms • Evaluate how the synthesis of key ideas of algorithms, data representation and programming are applied effectively when developing real world applications • Use an accepted software engineering methodology to design, develop, document and test a complex computer program.
Designing and Developing Digital Outcomes	
• Make decisions about the best tools/ techniques to solve a problem. • Work through an iterative process to design, develop, store, test and evaluate digital content to address given contexts or issues • Select software and file types for particular purposes • Use selected software to create an outcome • Understand the role of operating systems • Explain the conventions of storage • Understand the need for security and	• Integrate knowledge of digital applications and systems to create digital outcomes that meet design specifications • Discuss, design, construct and debug complex electronic environments and embedded systems • Effectively apply an iterative process to develop digital outcomes that synthesize end users' needs

Digital Fluency in the Curriculum

Explicit in the curriculum are the concepts of computational thinking and digital outcomes, but implicit are underlying concepts such as digital literacy and fluency. Interpretations of these latter (and associated) terms vary widely. Definitions of digital literacy range from the simple ability to understand and use information in multiple formats from a wide variety of sources (Bawden, 2008), though learners being able to express themselves and develop their ideas through ICT both for work readiness and as digital citizens (UK Department for Education, 2013), to competency in computational thinking (Park, 2016). Digital fluency has often been expressed more broadly. For example, the New Zealand Ministry of Education describes it as learning anywhere, anytime, with digital learning for every learner regardless of location (MoE, n.d.b). Spencer (2015) focuses more on tools and skills, such that digitally fluent learners can self-select from a range of tools to achieve outcomes, and navigate collaborative spaces effectively and confidently, while Park (2016) defines digital fluency as the set of social, emotional and cognitive abilities that enable individuals to face the challenges and adapt to the demands of digital life. Similarly, Resnick (2002) sees digital fluency akin to the fluency we develop with language; that we can not only use technological (and digital) tools but use them to construct significant things. He sees this type of fluency as powerful for lifelong learning. Digital fluency as a term lacks a single definition but it would seem that it can seek to develop important learner behaviours such as independence and flexibility.

The journey towards digital fluency

One way of approaching these multiple definitions is to consider whether there is some kind of progression of digital skills and activities that might outline the journey towards digital fluency. For example, Spencer (2015) suggests a progression from proficiency, through literacy, to fluency. In this view, fluency is dominated by aspects of digital citizenship. Similar themes appear in White's (2013) analysis, but he also emphasises topics such as collaboration, critical thinking and design skills. Miller and Bartlett (2012) also focus on criticality, which they break down into three components; net-savviness, critical evaluative techniques and diversity (of sources). A rather different three stage view is taken by Martin and Grudziecki (2006), who identify the stages of competence (skills, concepts, approaches, attitudes), usage (professional / disciplined application) and transformation (innovation / creativity). A further perspective is provided by Briggs (2011), whose distinction between the transactional (literacy) and the transformational (fluency) may provide something of a bridge between some of these other viewpoints. Here, fluency is knowing when to use the tools to achieve the desired outcome, and why those tools are likely to have that outcome. On the one hand, the concept of transformation, common to both Briggs and Martin and Grudziecki, suggests that there is a creative imperative to digital fluency. On the other hand, implicit in the approaches to digital fluency of White, Miller, and Bartlett and Briggs is the critical imperative. The NZ Ministry of Education's own definitions of digital fluency (MoE, n.d.c) are drawn from Resnick (2002), Miller and Bartlett (2012) and White (2013), so unsurprisingly gather together themes mentioned above. Here, digital fluency relies on a progression of skills from digital literacy (operational and functional skills related to digital technologies) to digital fluency (effective use of digital technologies in solving diverse, naturally-occurring problems in the real world). Further, that digital fluency incorporates both critical inquiry and creative practice. Table 2 summaries these various concepts of digital fluency, within which we define our own synthesis of the progression from operational competence to transformational fluency, and our definition of digital fluency as critical, creative transformation

Table 2: Concepts of digital fluency

Progressions	**Digital Fluency is:**
Proficiency -> literacy -> fluency.	Digital citizenship
Literacy/numeracy -> 21st century skills -> digital fluency (White, 2013)	Collaboration, critical thinking and design skills.
Competence -> usage -> transformation (Martin	Innovation and creativity
Net-savviness <-> critical evaluative techniques < -> diversity (Miller & Bartlett, 2012)	Criticality
Transactional -> transformational (Briggs, 2011)	Knowing when and why to use tools
digital literacy -> digital fluency	Solving diverse, real world problems, critical inquiry and creative practice.
SUMMARY From operational competence to transformational	SUMMARY Critical, creative transformation

A critique of the curriculum from the perspective of digital fluency

From the perspective of digital fluency, the structure and content of the digital curriculum raises some questions. For example, we might examine why technology is being split into the two chosen areas, and what this means for coverage of digital fluency. Is it covered by both sides of the curriculum up until year 10, or is it embodied in one or other of these two curriculum areas? Is this division, which seems somewhat arbitrary (storage versus data types, for example) purely designed to fit into assessment structures? Since the curriculum only refers to 'digital capability', one might question whether digital fluency is truly covered at all. We argue that digital fluency should be part and parcel of the entitlement curriculum.

Integrating digital fluency into curriculum design

From the discussion above, we note that a simplistic implementation of the digital curriculum up to year 10 might fail to deliver some key aspects of digital fluency. We are currently developing new course provision for in-service teachers that, while addressing the core components of the digital curriculum, will also integrate what we have earlier defined as the broader aims of digital fluency, namely critical, creative transformation. Through our examination of both the digital curriculum and literature in the area of digital fluency, we are integrating areas of technology practice that we believe can assist learners to develop these critical, creative and transformational skills that may otherwise be insufficiently emphasized in the curriculum up to year 10. Specific aspects of this approach include creative apps such as 3D Modelling, stop motion movie making, web design and mixed reality, while critical approaches are brought to bear in areas such as design thinking, agile and lean thinking, and the use of survey tools for student research, along with relevant analytical tools. Specific activities within these topics are designed to allow for reinterpretation by teachers and students to meet the needs of specific classes. We believe that transformation is only possible where students have sufficient agency over the activities they undertake within the curriculum.

Conclusion

Our experience with attempting to integrate the new digital curriculum into our own programmes, while paying due diligence to digital fluency in student outcomes, leads us to suggest a few recommendations for others working in similar areas. We suggest that digital tools that are used to address the curriculum are as broad as possible and make it easy for students to create digital artefacts. It is important to note that the creative potential of coding in programming languages by younger students is limited by time and complexity and therefore other approaches can often be more productive from a creativity standpoint. To assist students to develop critical skills, we believe that working in iterative, collaborative processes such as design thinking and agile teamwork can be highly valuable learning experiences, even if the outcome is not always a digital artefact. In terms of transformation, we suggest ensuring that activities based on digital outcomes are multi layered and use different digital tools in an integrated manner, such as designing an online survey, then gathering the data, then analysing it in various ways, and sharing and comparing conclusions. Implementing the new digital curriculum is a work in progress for all teachers across New Zealand, and we expect to continue to investigate ways in which it can be best employed to meet the needs of our students.

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