Digital Smarts

Enhancing Learning & Teaching

Edited by
Noeline Wright & Dianne Forbes

Wilf Malcolm Institute
of Educational Research
Te Pūtahi Rangahau Mātauranga o Wilf Malcolm
THE UNIVERSITY OF WAIKATO

Digital Smarts: Enhancing Learning and Teaching

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THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

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Introduction

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This book is a partnership on many levels—between co-editors, with and among the other chapter authors, external, international reviewers, and eventually with you, the book's readership. Our colleagues have also had to trust us in the mentoring, leadership and fruition of this project. We also hope that the work is trusted in the sense of having a quality assurance process that stands up as rigorous and befitting an academic text. We will address that aspect in more detail later in this introduction.

Partnership, trust and integrity are implicit in any edited book development that grows from within a shared context such as ours, the University of Waikato's Faculty of Education.

Where did it come from?

The book's inception was heavily influenced by international colleagues' books in both distance and teacher education where they too have collaborated with academic colleagues within their own institutions. Two such texts have been a particular inspiration: Atkinson and Claxton (2000), and Anderson (2008). They also worked with colleagues at their respective institutions. Atkinson and Claxton (2000), for example, challenged their authors to tackle and unpick one pivotal concept: the notion of "intuition" and what role it plays in teaching. Their text benefits from multiple perspectives and interpretations of the concept from across different domains (such as professional learning, ITE, continuing PD and assessment), while also pioneering a collaborative approach between the contributors as they worked together on the ideas.

In a similar way, Anderson's (2008) edited text, like ours, was mostly written by authors from within a single institution. Updated from a highly successful 2004 first edition, this text is a collection of work by distance educators, where each author addresses a component of the whole. Some chapters are mainly theoretical in nature, while others are more practically oriented. Overall, the chapters are representative of a community and are intended as a launchpad for reflection, discussion and action, inviting reader responses.

We liked the open-access character of Anderson and colleagues' work at Athabasca, the first university to produce freely available texts. We are also inspired by Anderson's reasoning for selecting the open-access format to foster knowledge-sharing and equitable access, intending it as a gift to readers to encourage the growth of ideas and knowledge. Freed from considerations of profit, like Anderson and colleagues, we can disseminate the work widely to prompt critical dialogue and reflection with a wider readership, we hope, than might otherwise be possible.

Our own collaboration also shares multiple perspectives on the notion of 'digital smarts' across a range of educational sectors and contexts. It brings a distinct institutional understanding to the scope of the book. This collaboration, while using rigorous quality assurance processes, means we can be in control the book and its publishing process rather than following the systems imposed by a traditional

publishing house. And we get to experience the layers of process involved in such undertakings in order to maintain a high level of academic rigour.

Digital texts and the social networks developing for academics (for example, ResearchGate, Academia.edu) can mitigate some effects of distance, population and price, but this also means texts need to be freely accessible. Current publishing arrangements through traditional academic publishers, as noted above, can be obstacles for teachers in schools, with access prevented unless a library subscribes to the text/journal or a reader is willing to pay for an article. Admittedly, publishing houses are recognising the growing clamour from academics that openly sharing our work to a wider public—particularly relevant in education—is important and must be available more widely than the traditional academic repositories and publishing houses. We want teachers to read this text, regardless of sector and access to academic libraries, so we have taken things into our own hands.

The book's format and quality assurance processes

Our isolation from the traditional main centres of academic publishing in the English-speaking world (such as the United Kingdom and the United States) meant we have done what our forebears have done—found a way around those impediments. To mess with Ernest Rutherford's comment about creativity and making do, since we don't have a lot of money or access to the readerships in other countries through the usual publishing means, we have to think of other ways to make things happen.

To that end, we have applied the peculiarly Kiwi Number 8[1] wire mentality to this project, choosing a digital format with a Creative Commons licence. Through an open source format and by making the text as widely available as possible, we hope to share this book with academics and practitioners across sectors, contributing to debate about the value of digital technologies in educational contexts.

Within the quality assurance process, this book is the culmination of a two-year process of collaboration. Contributing authors shared drafts at regular monthly meetings, leading to an open peer review of each other's progress. This open review phase had a number of purposes, including sharing and developing emerging ideas into something cohesive, with digital smarts as the glue. It was also for newer research colleagues to experience both sides of the reviewing process, a key quality assurance aspect of academic writing. Through access to each other's work, chapter authors could better see how their own work fitted the wider scheme of things. In turn, this assisted in refining and editing the chapters, thus contributing to a greater cohesion of the book as a whole. This has led us to organise the book in a certain way. We have put complementary chapters together, beginning with early childhood through to tertiary sociocultural educational contexts.

A final step in the chapter revision process was drawing on our international academic networks to provide external, blind peer-reviews before the chapters were finalised, formatted and digitised for open sharing.

To that end, we cannot thank the Wilf Malcolm Institute of Educational Research (WMIER) enough for providing us with the means to pay for the major costs involved, that of professional

[1] Built as we are on an agricultural backbone, Number 8 fencing wire has been relatively plentiful—it became the go-to resource for many things on farms.

proof-reading, graphic design and digitising. We also thank the University of Waikato's Faculty of Education for providing the context in which this book could grow.

Why 'digital smarts'?

We chose digital smarts as the key phrase for the book because we have appropriated it to encompass the following

- an emphasis on **pedagogy**
- **agency**, or students' active participation in their learning. This includes any learner in early childhood through to secondary and tertiary learning contexts where learners exercise agency over the focus of learning, generate content and resources, and are encouraged to provide feedback and feedforward to each other
- creativity
- **risk-taking**, experimentation, inquiry
- **challenging** the publishing status quo—managing our own workload, using open review processes, viewing assessment as learning, posing challenges for teachers and seeking open access to research publications.

In terms of using an e-book format, we make it easier for authors to include aspects such as:

- multimedia content
- small scale **case studies**—collectively a rich picture
- attention to **participant perspectives**—students, staff, researchers, authors.

The word 'smart' also links to an early statement by the New Zealand Ministry of Education in 2002 which talked about the 'smart use of ICT' in educational contexts. Over time, the sense of agency that the word 'smart' has for both learners and teachers has disappeared. More recent MOE statements about e-learning focus instead on describing the potential influence of the technologies on the learning, not the learning on the technologies and how they are used. We think it is important for digital technologies to be seen as the servants of learning, providing opportunities for all learners to be adaptive help-seekers and agents of their own lives as they appropriate these technologies as cultural tools (see Pachler, Seipold, & Bachmair (n.d.) for example, for an exploration of agency, culture, appropriation and the idea of the 'mobile complex').

We think the Ministry of Education's emphasis on the technology rather than pedagogy is misplaced. For example, the ministry's Learning with digital technologies page is mostly about ultra-fast broadband, not learning. The technologies should always be servant to pedagogy; teachers' deliberate planning that incorporates opportunities for students to learn through or with these technologies is what makes a difference—not the provision of technology itself. Evidence for our emphasis is contained in this book, where educators' thinking about how digital technologies are used for learning is the focus. It is this active thinking and pedagogical design that makes the difference to the value of the technology in a learning context, not the technology itself. Later in this introduction, we outline the ideas in each chapter that show how the author has approached learning with and through digital technologies.

This emphasis on the "potential influence of the technologies on the learning, not the learning on the technologies" also raises concerns about agency and the apparent diminishing of the teacher's role. Some technologies are dazzling but they end up overshadowing what we are in education for, which is teaching and learning—helping people learn how to think critically and deeply.

Digital technologies are helpful for teaching and learning but should never drive it. We need to always think, is this technology appropriate for my intended learning purpose? The technology should not be a solution looking for a problem (Campbell, 2001). With such an orientation, busy work rather than intellectual labour as part of longer term learning goals may easily eventuate. Our contention, therefore, is that being digitally 'smart' is about purposeful pedagogical thinking and practice: it is agentic. Digital technologies can help with smart endeavours but should never take over or drive them.

We are therefore reclaiming the word 'smart'. Having multiple meanings also makes it easy for our chapter contributors to interpret this term for themselves. For example, 'smart' can refer to 'smarting'—in the sense of being hurt, either physically or emotionally; it can also refer to creativity in the making of digital products; or the idea of a smart piece of work, something polished and sophisticated; or the degree of agency one exercises, such as in phrase *working smarter, not harder*; and we mustn't forget the 'smart' acronym for something that is Specific, Measurable, Attainable, Relevant and Timely.

These chapters are, we believe, the products of SMART thinking by the authors. What we are producing is *specific* (for it traverses individual education sectors, and is interpreted for the specifics of each chapter's context), *measurable* and *attainable* (in that the research has produced findings (attainable) arrived at through a rigorous process of investigation (in a sense they have been 'measured'). It is *relevant* (in that the book focuses on digital technologies in educational contexts) and *timely*. The here and now is always a good time to explore and share what is happening, suggesting implications for pedagogical practices across sectors. In other words, the term 'digital smarts' represents intelligent, pedagogically oriented and strategic uses of digital technologies to benefit learners of all kinds.

Introducing the chapters

In the realm of early childhood education, *Elaine Khoo* and *Rosina Merry*, in partnership with early childhood teachers and children, explore the impact of iPad use on young children's relationships and interactive learning. The authors interpret digital smarts in terms of quality pedagogy and the ways in which teachers responsively seize opportunities to extend children's interests, meaningfully integrating iPads into the teaching and learning context. Khoo and Merry emphasise, among other important factors, the agency of children, the awareness of teachers and the salience of learning alongside the affordances of iPads. Staying with an early childhood context, *Sara* and *Simon Archard* build on these themes with a case study of diverse and creative ways of using ICT to learn in early childhood. Central to Archard and Archard's work is the construct of digital habitus, representing the competencies and understandings that children bring from home to preschool settings. Their chapter examines the diversity of digital experiences and implications for teachers.

As in the first two chapters, *Garry Falloon* also presents a case study view of ICT use with children, this time in terms of digital learning objects in a primary (elementary) school. Falloon takes us behind the screens to share insights into how children interact with digital learning objects and with

each other. He explores the levels of thinking stimulated by the design of particular learning objects in a literacy learning context, indicating implications for future learning for primary school children. A challenge is issued to researchers and educators to develop smarter ways of evaluating the value of digital resources for learning.

These three chapters suggest to teachers and, by extension, to teacher educators, that in complex and changing times, it is vital to maintain our focus on quality learning in terms of higher order thinking, creativity and active decision-making, even when learners are very young. A key message is for teachers to recognise and celebrate student agency and diversity. These, and other chapters, reflect the importance of student perspectives on learning and teaching.

Kerry Earl shifts the focus to the preservice teacher education sector, surveying student perspectives on assessment within online courses. Earl proposes smart assessment design via short text assignments in a modular format as a means of enhancing student learning and balancing the complex demands of tertiary education. Her case study is illustrated with assignments from online courses, reflecting choice, variety and support for learning through assessment. Creative approaches to assessment incorporate tasks that are relevant to diverse students, enabling management of workload and digital affordances.

Further insights into initial teacher education are provided by *Dianne Forbes* in her chapter about negotiating guidelines for asynchronous online discussion with students. The idea is to elicit student perspectives and to surface their expectations of peers in online discussion. As students in each class contribute to shaping guidelines for working and learning together, the guidelines are passed forward as a legacy to subsequent classes as a starting point for renegotiating their own set of guidelines. In this way, each cohort of students contributes actively to decisions and protocols for working together, and each contributes to the learning of the next group of student teachers.

Noeline Wright's chapter moves the focus from online to in class, and from primary to secondary school classrooms. Her initial teacher education students needed to review their incorporation of digital technologies into specific lessons of their choosing while on practicum. She argues that it isn't enough to consider the uptake of digital technologies in terms of ease of use or satisfaction in getting a job done. For teachers, it's much more complex than that. Teachers—whether in ITE or in compulsory school classrooms—are much more likely to persist with using digital tools if their students broadly find favour with with them and if there appears to be a change in how they go about their learning. Wright appropriates the Continuance Theory model and applies the Kiwi Number 8 wire attitude to it. Through this appropriation, she suggests that for educational contexts, when digital technologies positively affect students' learning, task concentration and task completion, teachers will continue using these tools, even if some there are some impediments to doing so. Her pre-service teachers, many of whom were anxious about this task, were also keen to persist once their students indicated their positive responses.

Anne Ferrier-Watson looks at initial teacher education from another viewpoint, that of a librarian offering online support. She investigates how widely a specific group of online ITE undergraduate students use the virtual services of the library. She wanted to find out what sorts of library services these students valued, and what sorts of behaviours characterised their online library use. Her study sheds light on being digitally smart when learning at a distance. Through the lens of invitational theory, Ferrier-Watson examines the extent to which the university's library services provide an inviting and trusted support environment for these online learners. She unearthed the

striking influence of Google as go-to search engine: 65% of students surveyed used the general Google site to search, and just over a quarter of them used Google Scholar. However, more pleasing was that over half also used the university library's databases to search for texts beyond those in each course's readings. One finding was the frustration students felt when they searched for texts outside the university's library services, finding paywalls preventing access—perhaps prompting a turn towards the free library services. Another important finding was a lack of well-developed interpretive skills to make sense of options arising from search attempts. An important implication for practice is to help learners develop the critical and inferential thinking needed to navigate texts found via search attempts in order to select relevant items for reading and assignment tasks. This means greater links with academic staff to weave the library's key services into programmes that support this critical thinking need and improve the learning experience for all learners.

Pip Bruce Ferguson examines the value of an open peer review process to both reviewers and authors. Through feedback from four participants active in *Educational Journal of Living Theories* (EJOLTS—www.ejolts.net), she examines the value of such an open peer review process to developing transnational and cross-cultural research communities. Her four participants represented both experienced and novice researchers and reviewers. She wonders about the extent to which the online and open nature of the journal creates a digitally smart and connected community that exhibits the kinds of rhizomatic links George Siemen's (2004) Connectivism Theory sought to document. The chapter also calls into question the accepted blind review format, questioning also notions of academic rigour. Bruce Ferguson contends that the open review process is more robust than the traditional process because the communication between reviewers and authors means ideas and authorship can develop in a rich and meaningful way. It is certainly food for thought if we are to contest notions of academic publishing rigour and align the review process with a more supervisory and supportive process that appropriates digital smart technologies to facilitate a two-way process.

Digital smartness is next interpreted by *Stephen Bright,* who in interviewing a number of academics within the University of Waikato, but across a range of faculties, considers workload implications for those teaching fully online compared with partially or wholly face-to-face. He sought to find out from 10 staff what their experiences were like and how they managed their workloads. Those who taught fully online felt most able to manage their workloads and were happiest in their work. Those teaching a blend of face-to-face and online courses felt the most compromised and believed they were burdened with a heavier than usual workload.

His chapter segues well to *lisahunter*'s where she describes, via an autoethnographic approach, what it is like to newly arrive at the university and immediately begin teaching online while still getting used to the new systems and online processes, including the help function. Not initially knowing who to call or how the systems worked makes for a painful experience. She therefore explores digital smarts in terms of something being prickly or biting, playing on the concept of digital bytes and attending to the positioning of her academic pedagogical self. Her chapter concludes the book and identifies some of the issues academics can face when including digital technologies in tertiary learning contexts and when associated technical issues are not always known in advance, or when the help provided doesn't always match the support needed.

The book therefore spans a wide range of education sectors from early childhood contexts where young children use digital tools through to university academics teaching and learning online.

External reviewers

Our group of external reviewers also contributed ideas about being digitally smart, such as this being a term best understood through the lens of digital fluency rather than digital literacy. From an educational perspective it is about insight into the affordances of technologies and their application to different teaching and learning contexts. This relates to a critical appreciation of the opportunities for the effective employment of tools—an awareness of place and space for their use, addressing both the *when* and *why* rather than just the *how* of using digital tools effectively. In short, it is all about ensuring that the outcomes of using digital tools match the original intentions of the user.

Another external reviewer argued that digital smarts is no longer simply about basic information literacy or keeping your information safe and private. Digital smarts is about developing a positive and powerful digital identity, establishing a voice within a global network, and nurturing creative and inclusive communities.

We wish to thank our external reviewers for their advice and for being prepared to volunteer precious professional time. Their feedback to individual authors has been an invaluable contribution to the academic rigour of this book. Our external review group represented reviewers from Australia, The United Kingdom and Canada. They are (in no particular order):

Alec Couros
Steve Wheeler
Caroline Daly
Gilly Salmon
Richard Walker
Kevin Burden

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Chapter 3: Digital Learning Objects and the development of students' thinking skills

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Abstract

Over the past decade, considerable resource has been invested in the development of bite-sized web-delivered Digital Learning Objects (DLOs) designed to assist students to develop specific knowledge and skills. Initiatives such as the now-concluded Australian Le@rning Federation's DLO project and the BBC's Bitesize programme have resulted in online repositories of objects being openly available to teachers to integrate within their curriculum. However while these resources are readily accessible, uptake and use appears limited to being fill-ins or add-ons to other learning activities, rather than the result of deliberately planning to achieve a particular learning purpose.

This Digital Smarts chapter reports on a study that used an innovative methodology to 'go behind the screens' while students working in pairs used two specifically selected DLOs to help develop grammar and problem-solving skills. It used screen capture software to record video and audio data of their interaction with the objects, which was then coded against a thinking skills framework to identify object design and content features that triggered thinking of different types.

Data indicated very different levels of *thoughtful engagement* with each object, and notwithstanding their different purposes, suggests much can be done to improve the design and content of some objects to improve their learning performance. It also suggests that teachers considering using DLOs with their students need to be not only very specific in identifying appropriate learning objectives, but also critically aware of *how* learning objectives are represented and developed through the object's pedagogical design.

Keywords: learning, objects, digital, DLO, thinking, design, pedagogy

Introduction

The 'digital smarts' theme of this book is particularly relevant to this chapter in its exploration of new and smarter ways of using technologies to enhance teaching and learning, and to gather evidence of the impact it has on this process. It responds to this theme by offering a challenge to existing research methodologies in this area, and suggests we now have the opportunity to use more sophisticated digital tools to gather data that accurately represents students' digital interactions, so that educators are in a better position to make smarter choices about where and how technologies can add value to learning. The chapter has three purposes. First, it introduces a study that employed an innovative method for collecting *real time* data of student interaction with two DLOs of very different designs.

Second, it provides an analysis of these data against a thinking levels framework to identify content within the DLOs that stimulated higher and lower order thinking. Finally, it draws implications for teachers considering using DLOs in their classroom and argues that *smartly* selected objects can be valuable tools for teachers wishing to promote students' higher order thinking skills.

Learning objects of various types have been on the education scene for many years. But more recently, attention has turned to the potential of digital technologies—originally CD and DVD-ROM technologies and lately the World Wide Web—to act as delivery systems for objects of a more interactive and engaging design, able to be used and reused in a range of learning situations. These have become known as digital learning objects or DLOs. While contemporary definitions of DLOs differ, broadly speaking they can be described as "interactive web-based tools that support the learning of specific concepts by enhancing, amplifying and guiding the cognitive processes of learners" (Kay & Knaack, 2007, p. 6).

While in terms of the present pace of innovation it could be argued DLOs represent 'yesterday's technology', up until very recently significant resource has been targeted at their development in an effort to provide teachers with easy to access and use digital content, able to be selected and organised to meet the specific learning needs of students. An example of one such initiative is the Australian Le@rning Federation's DLO project, which from 2001 produced and indexed thousands of objects tailored to meet the goals of the Australian and New Zealand curriculums. Presently there are over 3,000 objects listed on the SCSEEC's Scootle website.[4] Despite this significant investment, commentators point to a dearth of robust research evidence signalling any substantial learning benefits from DLOs (e.g., Kay & Knaack, 2007, 2008; Nurmi & Jaakkola, 2007), while others remark on their variable quality and low uptake by teachers as an indication of their underwhelming success (e.g., Butson, 2003). Countering this are studies that suggest learner motivational and engagement benefits from DLO use, although these are speculative on learning gains and are generally student self-reports or teacher perceptions based on observational data (e.g., Cameron & Bennett, 2010; Gronn, Clarke & Lewis, 2006).

While it would be fair to say the jury is still out on the learning value of DLOs, much of this could be attributed to inadequacies in existing research methods to yield data that reveals a more complete and robust picture of how students interact with digital resources such as learning objects. Maddux (1986) and more recently Maddux and Cummings (2004) comment that this situation is not a new one. Maddux (1986) convincingly argues that history is littered with examples of educational innovations that have fallen victim to what he terms "the pendulum syndrome" (p. 27). This he describes as a situation where educational innovations are introduced amidst much fanfare and hype followed by rapid adoption by schools, only to eventually be abandoned when disillusionment sets in after they fail to meet over-inflated expectations. Technology examples listed by Maddux and Cummings (2004) include programming languages such as BASIC and Papert's LOGO, and student-centred Webquests.[5] Maddux and Cummings (2004) speculate that the failure of technology innovations to gain significant traction in education may not be because they are no good but rather

[4] Standing Council for School Education and Early Childhood. Refer http://www.scootle.edu.au/ec/search?contenttype=%22Interactive%20resource%22&sort=contentsource.sort%20asc

[5] An updated list might also include Wikis.

because researchers have inadequately communicated (and/or teachers have inadequately understood) the learning-theoretical foundation upon which effective use could be built. They comment that this leads to adoption decisions being made "because they [technologies] are there" (p. 523) rather than as a result of an informed process based on researched inquiry.

Digital learning objects

The coining of the term Digital Learning Object can be traced back to around 2000, when David Wiley completed his PhD dissertation, entitled *Learning Object Design and Sequencing Theory*. In it he argues the learning value of "instructional components" (objects) that can be reused and organised in different ways by teachers and instructional designers, according to different contexts and different instructional goals. He contends the Internet offers the ideal medium for delivery of these components, as it affords simultaneous access and provides the ideal environment where DLO developers can collaborate in refining and improving their designs. Other researchers have extended Wiley's ideas by suggesting a series of attributes that characterise DLOs from more conventional learning materials accessed online. These include scalability, adaptability, interactivity, reusability, inclusion of different media and graphical content, and accessibility (Ally, Cleveland-Innes, Boskic, & Larwill, 2006; Baki & Cakiroglu, 2010; Butson, 2003; Kay & Knaack, 2007; McCormack & Li, 2006).

Wiley's original argument was that digital learning objects could help teachers and instructors generate learning materials more efficiently, through being able to access small and discrete learning components able to be assembled into 'bundles' matched to instructional or learning goals. He claimed that the process of decomposition and re-composition (reconfiguration) of learning resources was a natural one for educators, who were required to do this by default to ensure materials were best suited to their students' learning needs. Using digital objects could improve this process by potentially increasing the speed and efficiency of instructional resource development, through "bypassing the initial step of decomposition" (Wiley, 2000,p. 2). Although improved learning efficiency claims hold undoubted appeal, some comment that their use for this purpose can encourage a reductionist view of learning manifested through objects delivering 'information bytes', rather than acting as conduits or resources supporting more active, deeper learning (e.g., Ally et al., 2006). This has contributed to investigation of alternative object designs, based in different learning-theory principles.

Ally et al. (2006) argue the desirability of learning objects being designed around more generative principles if they are to successfully accommodate the diversity of learner needs likely to be encountered in various learning situations. They comment that learning objects need to be dynamic and adaptable, thereby "provid[ing] opportunity to accommodate varying learners' readability levels, language levels and learning styles" (p. 46). They assert customisation or adaptability of learning objects is essential to ensure learners actively engage with them, and assist them to "foster understanding, facilitate the opportunity for self-reflection and support individual use" (p. 47). Their study of online learning objects used in a course involving 100 customer service trainees, pointed to the value of objects of an applied nature, containing practical training examples and exercises immediately applicable to the work of the participants. They linked successful use of learning objects in this programme to motivational advantages brought about by the 'learner focus' of object design and content, and their applicability to work and personal goals.

McCormack and Li's (2006) comprehensive study of learning object use involving 770 teachers across six European countries investigated their impact on teaching pedagogy. The European-Union sponsored project was part of a wider initiative known as Context e-Learning with Broadband Technologies (CELEBRATE). Teachers and their students were given access to a portal containing a large number of digital objects that they could select and use across a range of curriculum subjects. The objects were specifically developed to be consistent with constructivist-oriented design principles. This approach was chosen as it was considered to best support the generation of objects compatible with wider project goals, namely to "create citizens who can enter the workforce with the key skills required by the Information Society—collaborative working, creativity, multidisciplinarity, adaptiveness, intercultural communication and problem solving" (McCormark & Li, 2006, p. 214).

McCormack and Li surveyed teachers' perspectives on how flexible content enabled by the web-delivered learning objects impacted upon student learning processes and teacher e-Learning practices. Results indicated that while nearly 70% of teachers considered the objects as useful (or better) in their teaching, *context mattered.* That is, the value of particular pedagogical design and content features of objects was viewed differently by different participants, and this variation generally mapped back to their ICT skills and experiences and the school system in which they worked. For example, some French teachers criticised some objects for their "high-tech visual designs" (p. 222) as this suggested they were more like games than learning resources. Additionally, 60% of all teachers indicated difficulty incorporating the objects into their programmes. Technical considerations also figured strongly, with infrastructure, network and compatibility problems affecting the quality of access and ease of use of the objects. Issues with standardisation of object media also became apparent, as not all teachers had access to correct versions of the players needed to run embedded video or audio content (e.g., Flash, Shockwave, Media Player).

However, despite these issues, teachers strongly supported the value of objects as helping to improve their teaching and enhancing the learning motivation of their students. Many appreciated the specificity of some objects—in particular, their modular nature that better supported incorporation into curriculum. It was this 'fit' characteristic above others—such as granularity and interoperability (Wiley, 2000)—that had the most influence on teachers' perceptions of the value of the objects. Furthermore, it was found that despite object designs being based on constructivist principles, teachers would adapt the way they were used to suit their own context and pedagogy. While McCormack and Li (2006) claim this did not diminish their effectiveness, they did comment that "teachers are likely to superimpose their own pedagogy on any LO, whatever the 'designed' pedagogy" (p. 228).

McCormack and Li's conclusions add limited weight to Wiley's original argument about objects offering cost-effective learning efficiency benefits through reusability and flexibility, but tend to suggest the importance of context in achieving these gains may have been understated. This notion finds support from Nurmi and Jaakkola (2006), who argue that in appraising the worthiness of objects, one cannot separate them from the context in which they are used. They claim that objects are an artefact of time and place, and to make them universally applicable in the way Wiley originally intended, it would require a 'peeling off' or detachment of the content from their original context and developmental environment. To do so, they state, would represent an "objectivistic conception of truth and knowledge" (p. 272) and encourage an "unfortunate emphasis on knowledge transmission" (p. 274) as the driving purpose for object use. Using objects primarily for content delivery severely

limits their value as resources for supporting deeper learning and knowledge construction. While Nurmi and Jaakkola agree the concept of objects is basically sound, they call for a reconceptualisation of their design and purpose to move thinking away from the object as learning objective to the object as a means to engage learners and elevate learning processes and experiences. They sum this up nicely by stating, "learners should learn with, rather that from, learning objects" (p. 280).

This debate has stimulated considerable research into the design of DLOs for different learning purposes (Kirschner, Sweller, & Clark, 2006). Much of this has centred on the function of *structured* vs *open-ended* object environments, where some argue the need for sufficient structure to provide enough guidance to enable mastery of key learning concepts—especially where existing conceptual knowledge may be limited (e.g., Mayer, 2004). Others suggest that deeper and more robust learning occurs when learners interact in open-ended environments and are supplied with a range of tools they are able to select and use as they see fit, to solve higher-order problems (e.g., Steffe & Gale, 1995; Vannatta & Beyerbach, 2000). When considering these arguments in relation to DLOs, a case could be made for designs reflecting both views, with selection and use decisions being made by teachers according to the needs of their students and teaching and learning goals. It also suggests selection of objects taking into account contextual, design and content features such as those described above may be an important element in making smart decisions about their use.

Research goal and questions

Seeking more information about how digital learning objects of different designs can influence the nature of student thinking, the following study mapped a group of primary-aged students' learning interactions with both structured and open-ended objects. Its aim was to reveal information about the type and nature of their thinking while they were working in pairs on objects of each type, and to identify features and content of the objects that appeared to stimulate thinking at different levels. Data collection was guided by these research questions:

1. What differences, if any, exist in levels of student thinking when using digital learning objects of structured and open-ended designs?
2. What design or content features of digital learning objects of each type appear to stimulate thinking at different levels?
3. What implications are there for teachers selecting and using digital learning objects in their classrooms?

Research context

The study was undertaken in a class of 29 year 5 and 6 students (9–11 year olds) situated in a small semi-rural school in the Waikato region of New Zealand. Typically, New Zealand primary schools cater for students from year 1 (5 year olds) through to year 6 (10–11 year olds), with some extending to include year 7 and 8 students (11–13 years). The research class comprised 13 girls and 16 boys. The teacher was an experienced practitioner, having taught at the school for 10 of her 18 teaching years. I approached her to participate in the study following previously successful research involving

the use of digital technologies in a school-scientist partnership (see Falloon, 2011, 2012). During these earlier studies, the teacher had displayed an innovative and open disposition and flexible approach towards using emerging technologies with her students—qualities desirable in this study also. Additionally, she had available a set of netbook computers (n=15) that would be sufficient for paired access to the web-based objects, via the school's WiFi network.

The teacher selected the objects to support specific curriculum goals in literacy (grammar—parts of speech) and problem solving/decision-making. The objects were sourced from the New Zealand Ministry of Education's Digistore (part of the Australian Le@rning Federation's DLO repository). During the eight weeks over which data collection took place, the students accessed and used eight objects including some with multiple levels or versions. A full list of these is included in Appendix A. While eight objects in total were accessed, two were selected for analysis. These were 'Finish the Story: Bushfire' (parts of speech) and 'Catch the Thief': Level 2 (problem-solving/decision-making). These two were selected as they represented the clearest examples of objects based on structured and open-ended design principles (respectively), and were accessed by all students.

Research method and data collection

The study adopted conventional case study methods located in an interpretive theoretical framework. Case study method was chosen as it supported intensive inquiry within the confines of a bounded unit of analysis. It provided a structure for targeted but sustainable interaction that yielded data providing rich visual and audio information about these students' learning pathways with DLOs. Data were collected over an eight-week period at different times of the day, and on different days each week. This was done to randomise data collection, to emulate probable 'normal' classroom use patterns. Unlike more conventional case study methods, a technical recording solution captured video and audio data while the students were using the objects, via an installed app called SnagIt.[6] SnagIt records as an .avi movie what is displayed on the netbook's screen, along with audio through the built-in microphone (see Figure 1). This allows both system sound (i.e., sounds associated with the learning objects) and students' discussions to be recorded. The recorded movies and sound were stored on the netbook's hard drive and later transferred via USB drive to my laptop for analysis.

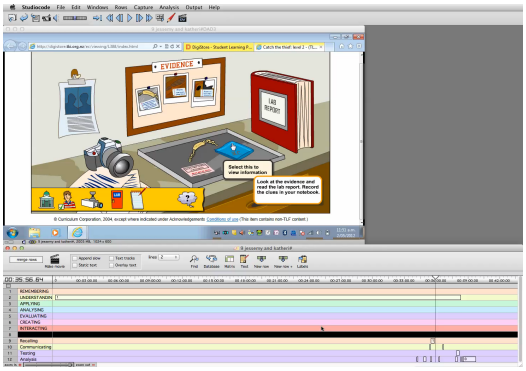


Figure 1: **A typical screen capture recorded by SnagIt and the Studiocode timeline (selection not used in analysis)**

[6] See http://www.techsmith.com/snagit-gslp.html?gclid=COigq4zCsLgCFQghpQodg2YAJw

A multi-user licence allowed five installs of SnagIt, and these machines were rotated around the pairs over the course of the eight weeks to ensure all students were recorded. A typical recording session lasted between 25 and 35 minutes, with student pairings being changed regularly. In all, just over 13 hours of video and audio were captured, representing the interaction of 16 unique student pairings with the objects. From this, all recordings of students using *both* 'Bushfire' and 'Catch the Thief' were collated for analysis. This equated to three hours 27 minutes of recording involving nine pairs.

The two objects for analysis were chosen because they represented the best examples, from the ones selected by the teacher, of objects based on quite different designs. This enabled a comparison to be made between how students responded to the content and structure of both objects and the influence of these on their interaction and thinking. The 'Bushfire' object was of a linear design, with students needing to follow a predetermined interaction pathway with its content. The object, via the characterised editor, effectively dictated the navigation route available to the students from start to finish through sequential activation and deactivation of menu options and content organisation that required students to have at least visited previous screens before moving on to the next one (Figure 2). 'Catch the Thief', however, represented a totally different, menu-driven design, where students were able to generate their own interaction pathways and access content as and when required. While the object placed some parameters around that interaction—such as having to go back to the police station and check their evidence if they chose the wrong suspect—these were generally of a scaffolding nature, cleverly designed to avoid students immediately re-guessing or adopting a 'process of elimination' strategy. Apart from design constraints such as this, students were free to choose which venue they gathered evidence from, when and how they used and recorded that evidence (some used pen and paper), what evidence they compiled into their dossier, and how they selected their suspect from the 'line-up' (Figure 3).

Figure 2: **The object, via the characterised editor, specifies the sequence of activity**

Figure 3: **Selecting suspect matching the evidence in dossier**

Data coding

I made the selection of pairs whose data are included in the Results tables with assistance from a postgraduate research scholar employed under the University's research scholarship programme. Nine student pairs accessed both objects during the period of data collection, and six of these completed each within a single recording period. This is important as using data from pairs whose interaction with a single object spanned more than one recording session was problematic, as they generally restarted the object afresh each time or recommenced at a different place from the previous use. From the six remaining pairs, four were chosen for analysis based on the quality of the data recorded by SnagIt. The decision about 'quality' was negotiated following independent appraisal of the six samples by the research assistant and me, using the following criteria:

1. The extent to which the recordings provided insights into students' thinking and decision-making strategies;
2. The extent to which the recordings illustrated a range of object interaction approaches and strategies;
3. The nature and volume of interaction between the students;
4. The quality of the recorded video and audio (a minor consideration but important for extracting screenshots and video data excerpts).

After discussion, it was also decided to include an additional pair (M&Y) in the data set for 'Catch the Thief' as they displayed particularly high levels of oral interaction that gave excellent insights into the strategies they used to solve the crimes. The other four pairs selected were (first initials only) P&A, J&D, J&K and D&C.

To assist decision-making relating to the complexity of thinking skills students displayed while interacting with the objects, a draft series of descriptors were developed based on Anderson et al.'s (2001) revision of Bloom's Taxonomy (cognitive domain). These descriptors interpreted the six thinking levels represented in the taxonomy in relation to video or audio evidence of students applying these to solve problems or overcome challenges presented by the objects. A summary of the type of evidence used to make these decisions and the way this was interpreted is included in Table 1. To ensure a level of consistency of interpretation against these descriptors, M&Y's video was used to 'calibrate' the scale. To achieve this, data were imported into Studiocode[7] and independently blind coded by myself and the research assistant.

Studiocode enables events contained in video data to be 'tagged' to align to specific themes (macro and sub-codes) identified by an analyst. These are pre-entered into a coding window and relationships mapped, indicating sub-codes linked to main codes. A timeline containing the codes and sub-codes is created for each video, and clicking on the relevant code button activates and deactivates the recording of an instance related to that code from the video. These are grouped so that all instances aligned to the code can be replayed by clicking on the respective code button to the left of the timeline. Alternatively, single instances can be accessed by clicking on the relevant entry point on the timeline (see Figure 1). Entries can also be tagged with text to highlight their significance or add additional information.

Table 1: Framework describing video evidence aligned to levels of thinking (adapted from Anderson et al., 2001)

Level	Description of evidence from video recordings
1. Remembering	Evidence of dialogue or action indicating **recall** of known facts or relevant data (e.g., spoken, graphical, textual) and/or previously learnt procedures or processes of various types to solve problems or meet challenges presented by the object.
2. Understanding	Evidence of dialogue or action indicating or contributing to student comprehension and/or improved clarity relating to learning ideas embedded in the object, and/or instructions or procedures and processes required to solve problems or meet challenges presented by the object.
3. Applying	Evidence of dialogue or action indicating the **recall** and **application** of known facts, other data, processes or procedures of various types and from various sources to solving problems or

[7] See http://www.studiocodegroup.com/?page_id=77

	meeting challenges presented by the object.
4. Analysing	Evidence of dialogue or action indicating reflection on the outcome of the application of learnt facts, other data, processes or procedures of various types and from various sources required to solve problems and meet challenges presented by the object. This may involve deconstructing and critiquing outcome/s or responses and speculating on possible revisions.
5. Evaluation	Evidence of dialogue or action indicating the scrutinising, appraisal, prioritising or ranking of data and/or processes and procedures of various types and from various sources, to solve problems or meet challenges presented by the object.
6. Creating	Evidence of dialogue or action indicating the use of data and/or processes and procedures of various types and from various sources, to the production of new and original content to solve a problem or meet challenges presented by the object.

Copies of M&Y's data were installed on separate computers, and the assistant and I independently coded that data against the six levels of the descriptor framework. As the videos played, incidents or events we deemed to be aligned with the different levels of the framework were entered onto separate timelines. When completed, these analyses were compared using Cohen's coefficient for inter-rater agreement. Consistent with Gwet's (2012) recommendation for handling missing data, calculations were restricted to occurrences that we both identified, to avoid the possibility of underestimation of agreement due to the inclusion of data upon which no agreement was reached. In total, 29 agreed-upon incidents were coded at all levels of the framework. A summary is presented in Table 2.

Table 2: Inter-rater agreement calculation for M&Y

Rater	A	B	Total
A	11	4	15
B	2	12	14
Total	13	16	29
κ=.588	SE=0.1	CI=.297-.879 (95%)	
	49		

While the result was reasonable (moderate) according to Landis and Koch's (1977) often-cited guidelines for inter-rater agreement, working together we re-analysed M&Y's video in an effort to reach better agreement on level interpretations. During this exercise each of the 29 agreed-upon incidents in M&Y's video were re-examined, and the allocated levels debated. From this, we achieved greater clarity and consistency in identification of level attributes recorded in the videos. A second

calibration was carried out on another pair's video (C&S—not included in the sample) that yielded 34 agreed-upon incidents at κ=.706 (SE= .121; 95%CI=0.468-0.944). This indicated a good level of rater agreement (Landis & Koch, 1977) and supported confidence that reliable interpretations would be made. The research assistant then proceeded to code the eight remaining data samples, using the C&S example as an interpretation 'template'. He then generated an interaction graph for each pair similar to the ones presented in the Results. The graphs represent a timeline of student progress through the object mapped out in 10 second intervals, with vertical bars projecting to different 'thinking levels' according to the rating given. Multi-coloured bands were collated at the top of each graph, indicating broadly the location or activity within the object each pair was engaged with at the time of rating. While the bars displayed in the graphs suggest a 'one point in time' interpretation, it should be noted that on occasions recorded dialogue or action spanned several seconds. Therefore, the narrower bars should be viewed as an approximate location only. They have been used in the Results to enable presentation of data in a way that allows comparisons to more easily be made between the pairs, using a single graph.

Results

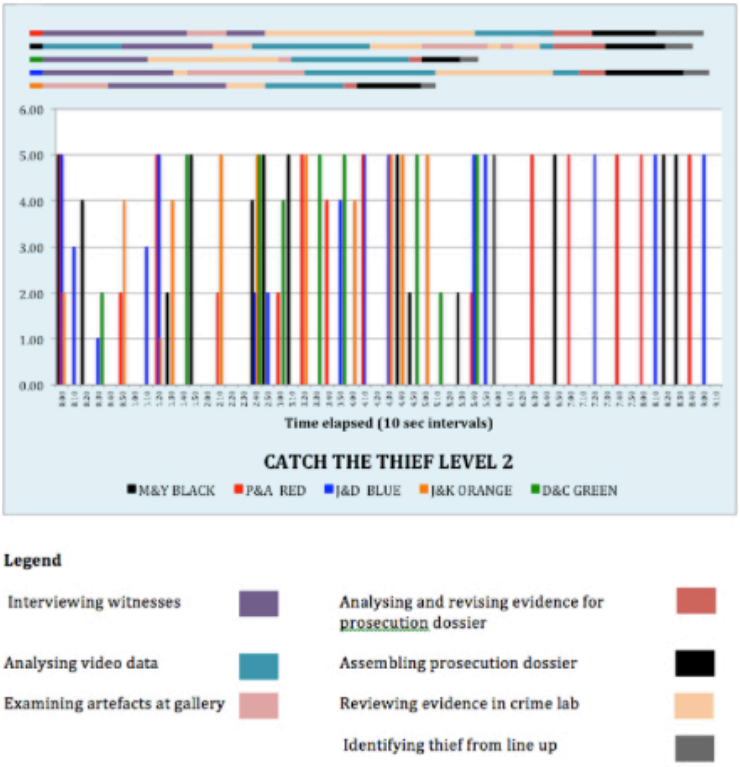
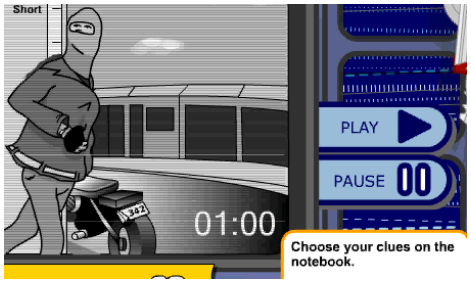
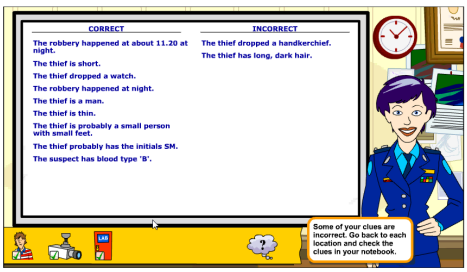


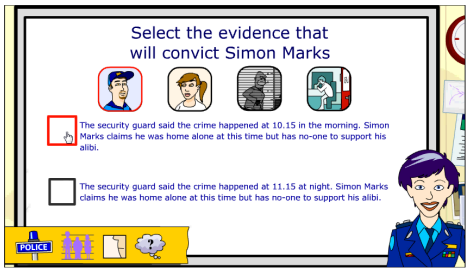
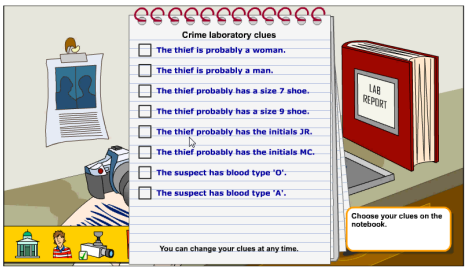
Figure 4: **'Catch the Thief' timeline/level ratings for all pairs**

The timeline charts below (Figures 4 & 5) illustrate the 'thinking level' ratings given to the pairs as they completed the various tasks required by each object (at 10 sec. intervals from commencement). As each pair progressed at different rates, coloured bands have been used at the top of each chart to indicate approximately how long they spent engaged in each activity. These activities are explained in

the 'object action and description' column of the data summary tables (Tables 3 & 4), along with a thumbnail image associated with the activity and samples of recorded audio and/or explanation of observed video interaction. These interactions have been given approximate time logs that relate to the time spans indicated by the bands at the top of the charts, and thinking level ratings (e.g., L2), as represented by each chart's bars. An additional rating (L0) has been added to some comments made by the students in the 'Bushfire' object. While they did not meet the level criteria laid out in the descriptors, they were included because they provided useful insights into the strategies and approaches some pairs applied in dealing with the object's content. In some examples they illustrate clearly the level of disengagement some felt with the content and the way it was presented, and how they managed to bypass it to complete tasks more quickly.

	Object action and description	Thumbnail image	Sample Recorded Interaction
	Interviewing witnesses (security guard and Robyn Wallace). Students listened to oral reports from eye-witnesses to the crime in the gallery (what did you see? What did the person look like? Do you remember what the person was wearing?) They checked off clues provided by the witnesses in their clue notebook for this venue. Not all clues were relevant. Some students interviewed witnesses individually and entered details in the clue notebook, while others did this collectively. Students could revisit the gallery to revise or re-record clues as required, by reselecting from bottom menu.		"OK, so he said it happened at night… it was dark… write that down" (J&D, 0.30) (J&D used pencil and paper to record clues, as well as notebook checklist).)(L5) "So… let's see… she said they were quite short… go back to the start and write everything down… get a piece of paper and a pencil… we need to check… have a look at the camera (CCTV)… we need to see if she's right…" (P&A, 1.18, L5) "The woman said he was wearing a balaclava (Y). What's a balaclava? (M). Something you put on your head, I think (Y). We need check… get the dictionary (M)" (M&Y, 1.46, L5) "We have to ask them questions… that's what we have to do" (D&C, 0.33, L2)

	Analysing video data Students were able to access CCTV video of the suspect 'getting away'. Typically, this provided information on time of day or night, the height of suspects, mode of transportation (and sometimes identification details), clothing worn etc. Students checked off clues in their notebook for this venue. Not all clues were relevant. Students could pause or replay video as required.		"Replay the camera J, I'm not sure about the time… I think they had 11 something, but that cant be right…" (J&K, 4.38, L5). "Pause… pause the thing (video). Let's see… it must be a woman 'cos (sic) she's short… (P). But you can have short men too so don't be too sure… and it's hard to tell if they're fat 'cos of the coat (A) (P&A, 6.27, L5). "I don't think we've got that right. Check the number plate again…" (J&D, 3.48, L4)
	Examining artefacts in the gallery Students could examine artefacts in the gallery that provided pop up information panes about the artist, year of production etc. This information was a 'red herring' as it provided no clues helpful in solving the crime. One pair (J&D) spent considerable time examining artefacts and appeared confused about their relevance.		"… who's Ned… Kel…Kelly? (P). I dunno (sic) (A). I don't know either… and what d'we (sic) have to do with these things (gallery artefacts)? (P) I think we're s'posed (sic) to look at them" (A). (P&A, 2.08, L2). "Click on the paintings (J). (Reads some of description). D'ya think they have something to do with it? Don't know… maybe click on the vase thing on the floor… could be a clue… that's how we got the others" (D). (J&D, 4.38-4.45, L2)
	Analysing and revising evidence If students have incorrectly recorded any clues from the lab, security video or witnesses, their selection appears in the right hand column. Students must decide which venue notebook the incorrect clue comes from and go back to that notebook and revise their decision.		"We got some wrong. Go back and check what he dropped outside… we have to look at the video again (D). Yeah… and we should check the lab too… there was something in there, eh… that bracelet thing had some letters on it" (C) (D&C, 4.54, L4). "D'ya remember the shoe size… what was it again… 7 or 8? (M). I think it was 7… but is that small? It only says small feet… it

			doesn't tell us what size" (Y) (M&Y, 6.46, L5) "Did you see something about blood type… where's the blood type? We didn't get it. Go back to the glass… where he got cut" (J&K, 3.58, L4)
	Assembling prosecution dossier Students are required to collate evidence collected to assist the prosecution case. At the police station, they are prompted to select from two scenarios based on evidence from each venue. If they select the incorrect scenario they must revisit the venue to check their evidence. The object does not allow them to immediately select the other scenario.		"(J. reads description of first scenario aloud) It was at night… so that one can't be right. What does the other one say (begins to read second scenario). Night… it did happen at night, so… (ticks checkbox)" (J&K, 4.55, L5). "We need to work out which one's the most right" (D&C, 5.08, L2). "She's lying (Joanne Reynolds – suspect)… the time thingy had 1, but the shopkeeper said it was 12…" (J&D, 8.08, L5)
	Reviewing evidence in the crime lab The crime lab provides forensic evidence. Students examine each exhibit for possible relevance. Notes are available in the lab report book, but wordy format discourages use. Only one pair (D&C) carefully reviewed the lab book. Others spent time in the lab, but didn't scrutinise lab report in depth.		"We have to look for clues here… click on the things" (exhibits) (P&A, 2.58, L2). "No, we need to read the lab book… (pause…) look… see, blood type O… and it must be a woman 'cos it says the hairdresser only has women… you know, the card we found… it's ***all*** in here" (D&C 1.44, L5). "To JR from PT (referring to initials on bracelet)… Joanne Reynolds… JR… go back to the video and see what they dropped…" (J&K, 2.38, L5).
	Identifying criminal from suspect line up Students match their evidence to the range of suspects in the 'line up'. Each suspect has a description corresponding to available clues. If students do not identify		"She's got B blood but not the right shoes… she's got 8s and in the lab book it said 7, didn't it?" (D&C, 5.44, L5). "You can't tell by the hair, 'cos they had that thing on their head (balaclava). But it says she has a

	correctly, they must revisit their dossier at the police station.		motorbike… and… um… 342, the numbers match… (referring to number plate) (P&A, 8.36, L5).

Table 3: 'Catch the Thief': Description of object task, thumbnail and sample interaction

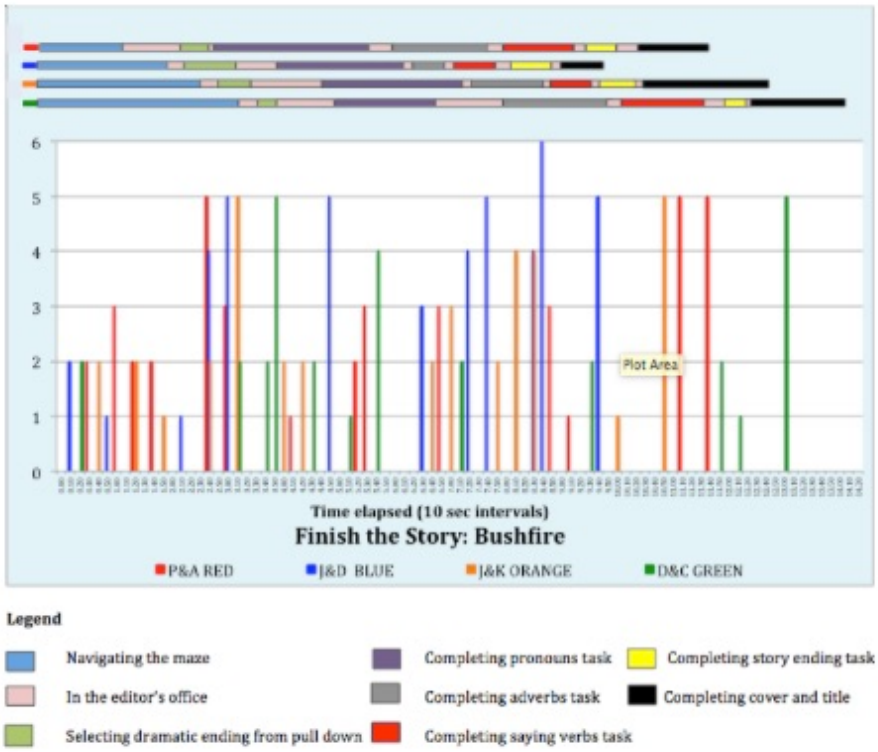
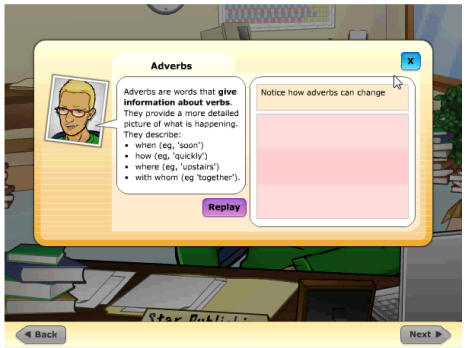
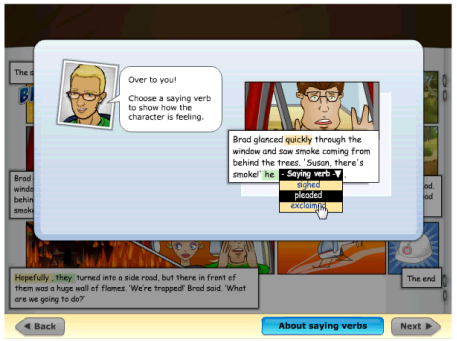


Figure 5. **'Finish the Story: Bushfire'. Timeline/level ratings for all pairs**

	Object action and description	Thumbnail image	Sample recorded interaction
	Navigating the maze Students 'drove' the vehicle through the maze avoiding the fires to get to the editor's office. This was the first task for all pairs upon entering the object and was set by the object's design. The time it took pairs to navigate this depended largely upon their keyboard coordination skills.		"… are we doing this right? (J) Who knows…! I think we have to dodge the fires… to get where we need to go (K)" (J&K, 0.42, L2) "It says here we have to help them escape the fire. You need to drive carefully, C" (D&C, 0.22, L2) "Remember what the arrows do… you gotta (sic) let it go if you want it to stop…" (J&D, 0.08, L1) "OK, so we've gotta drive to the finish. You any good at driving, A? (P&A, 0.26, L2)
	In the editor's office Students visited the editor's office on regular occasions to get instructions for the next part of their 'assignment'. All pairs accessed this part in sequence, as it was set by the object's design. After the first couple of visits, time spent here diminished significantly for most pairs (see timelines). Text heavy instructions and formal content design seemed to trigger disengagement.		"… this seems really hard (J). Na… just go next… can't be bothered. We managed last time" (D). (J&D, 2.08, L1) "We have to improve the comic… that's what he's told us" (P&A, 1.38, L2) "Swap the words… just swap the words… blah blah blah… (referring to editor's explanation) (D&C, 3.14, L2). "Just go next… (pause approx. 10 sec). Oh… we need to see what makes the most sense" (referring to story ending) (J&K, 2.42, L2)

	Selecting a dramatic ending from options Students are able to select from three options an ending to the story. All nine pairs reviewed the options before selecting. Some discussed what they considered to be the 'best' option and why (n=4), while remainder appeared to chose randomly ("this one will do").		"They wouldn't hide in a cave, 'cos they could be cut off… and the car would burn. Use the helicopter one…" (J&D, 2.56, L5) "Which one's best…? (J) Choose 1 (K). (reveals helicopter). No… how's it going to land? They need to find shelter – try 2… oh… a cave… (pause) and (presses 3)… a car. The cave'll (sic) do" (J) (J&K, 3.08, L5) "The helicopter's best. They need to get away… (P&A, 2.37, L5)
	Completing the pronouns task Editor introduces personal pronouns as a means of linking sentences in a narrative. Students have to select the 'About Pronouns' button before the 'Next' transition becomes active. All did this, but only three pairs provided evidence of interaction with the information in an effort to understand pronouns. In the next screen, students select correct pronoun from pull down list. Three pairs provided indication of engagement with text to determine best option. Five pairs guessed or selected through elimination. The strategy for one pair was undetermined.		"Blah… blah… blah. Don't replay it ('About Pronouns' information)… no… no… just hit Next" (J&D, 4.26, L0). (After pressing 'About Pronouns' button) "Who cares… don't need to know about that… we get it…" (D&C, 5.12, L1). "Him and Brad… (laughs). 'They'… no, doesn't sound right… must be 'She'… yeah… 'She' and Brad… (J&D, 4.48, L5). "What did we have to do again?(A) (flicks back to 'About Pronouns' – didn't read). Just guess! (P) (selects 'They' followed by 'She'). (P&A, 3.20, L0) "Who… who turned a bend in the road…and saw more smoke and flames… um… let's see… must be 'They'… there's two of them" (J&K, 6.58, L3)

	Completing the adverbs task The editor invites students to improve the story by using adverbs. They are required to select the 'About Adverbs' button before moving on to the revision phase. All pairs did this because they had no option, but only 3 provided any indication of interacting with the explanatory text. In the task, four pairs provided indication of engagement with text to determine the best option. Three pairs tried each option until the correct one was selected. The strategy for two pairs was undetermined.		"I can't be bothered listening to him (editor about adverbs)… just go on" (P&A, 5.50, L0) "Adverbs… which one makes it sound best… d'ya think… try the list… (pull down options)" (P&A, 6.46, L3). "We'd better read it… (after choosing incorrectly first attempt) (pause)… it must be 'Then'… the others don't make sense… (J&K, 7.48-8.08, L2-4). "Just guess till we get it right…" (options eliminated until correct one discovered) (D&C, 8.20, L0). "Brad glanced 'how' (J)… 'quickly'! (D) through the window…"(J) (J&D, 6.27, L3).
	Completing the saying verbs task After visiting the editor's office again, students are required to choose 'saying verbs' to describe how the characters speak. One pair paused briefly on 'About Saying Verbs' screen. Eight pairs immediately closed this window. Three pairs provided indication of some engagement with text to determine best option. Four pairs selected by elimination or guessing. The strategy for two pairs was undetermined.		"Brad glanced quickly through the window and saw smoke… Susan, there's smoke he… (reading text).. can't be 'Sighed'… that's boring and we're supposed to make it exciting… 'Pleaded'… (laughs). 'Exclaimed!' That's more like it… (J&D, 7.37, L5). "Not another one… just guess again… how many more do we have to do?" (P&A, 8.08, L0). They proceed to select options in order until correct one selected. "doo… doo… doo (singing) 'Reported'.. no that's not it… (J)… oh… 'Cried' try that (K)… yeah, good guess! (J) (J&K, 9.15, L0)

	Completing the story ending After completing the improvements, students are presented with a final version of their story, and invited to compose a conclusion. All nine pairs accessed this screen (dictated by the object's design). Four pairs developed content (of variable quality). Five pairs bypassed this screen and the one following it (text-only version of story) without adding content.		" Just hit next… (goes to text story page)… OK… (pause)… (presses 'Next' and goes to cover page)… Oh look! (starts composing title). (P&A, 9.50, L0) "Who gives…? (J). What are we gonna (sic) write here? 'Luckily the helicopter came just in time before they melted away' (laughs)" (J&D, 8.38, L6) "Just write anything… (C) (D writes 'theres a firer engen hiray!') That'll do!" (D). (D&C, 12.10, L1) "Oh, what are we gonna (sic) do? I know… (types 'run out and commet suicide. Great work Brad. Lt's go!) (J&K, 9.55, L1)

Table 4: 'Finish the Story: Bushfire'. Description of object task, thumbnail and sample interaction

Discussion

In interpreting the results it needs to be remembered that the two objects selected were of very different designs for very different purposes. 'Catch the Thief' with its flat, menu-driven design allowed students to develop their own pathways through the information and clues, assembling and recording them in any order using whatever system they preferred. They were also able to retrace their steps to check clues they may have missed or incorrectly interpreted, or replay evidence from the video, eyewitnesses or the crime lab. Active fields in the content of the object required student interaction to gather evidence, and they could record outcomes from this in the detective's notebook to be collated later when forming the prosecution dossier. Clever design meant that students were unable to guess or use trial and error to discover correct combinations. Instead, once an initial incorrect response had been lodged, alternative fields became inactive and a prompt was given to go back and check on clues at the various venues before assembling them again at the police station. The presentation of evidence in different formats (oral—eyewitnesses; visual—video and other venue visual clues; written—the crime lab report) required students to interpret, synthesise, compare, contrast and evaluate different data to identify patterns that could be used to build a case against different suspects, most of whom matched, in some way, more than one piece of evidence.

There was little doubt that pairs found the theme of the object engaging; that is, what they were required to do and the choices open to them regarding how they could go about it. This was clearly evident in the recorded comments, the universal level of enthusiasm they displayed towards catching the criminals and their repeated use of the object. The way the object was designed required their active cognitive engagement on every screen, and this in turn triggered significant discussion between students as they debated the merits of the evidence and developed strategies and approaches to collating it for their prosecution dossier. Good examples of this are included in Table 3, where students are required to analyse and revise evidence (D&C, M&Y, J&K) and D&C's comments when reviewing evidence in the crime lab.

In the timeline data, there is a loose clustering effect and spiking in the thinking ratings around activities where students were required to evaluate and collate evidence at each of the crime scene venues. This is also visible when they were assembling the prosecution dossier, with the discussion and screen interaction of most pairs regularly indicating thinking at level 4 (analysis) and level 5 (evaluation). At these points, interaction typically indicated high levels of reflective analysis and re-analysis and revisiting of data, as students debated the relevance of the clues presented to them in building a case against the suspects. Some aspects of the design of this object supported these processes. Built-in structural scaffolds such as button deactivation and verbal and visual prompts required students to revisit crime scene venues. They were unable to progress by guessing or trial and error, as once they had made an incorrect accusation or compiled inaccurate evidence, the option of selecting a different combination before rechecking was disabled.

The presentation and design of clues also encouraged students to evaluate and analyse, often by presenting only a small part of a larger clue that they needed to logically link to other parts. A good example of this was a business card dropped at one of the crime scenes *possibly* by the suspect, indicating a hair appointment at a 'Salon for Women'. Students needed to link this clue to a small (but size unspecified) footprint found at the crime scene to work out that the suspect was most likely a short female. They were also required to be critical in their appraisal of possible clues, as some elements of the object that gave the appearance of being clues were actually 'red herrings'. This particularly applied to artefacts in the gallery, some of which contained information unrelated to solving the crime. Examples of the effect of this on two pairs can be seen in Table 3, 'Examining artefacts in the gallery'. While interaction with these ultimately did not affect a successful outcome, for some pairs it prolonged the period required to solve the crime (e.g., J&D).

Another interesting feature of 'Catch the Thief' was its blending of oral, visual (static and video) and textual information in its presentation of clues and instructions. Students repeatedly accessed video and audio information, these appearing to be their preferred means of gathering and interpreting data contained in the object. Interestingly, the virtual lab report book that contained excellent summaries of forensic evidence that could have helped shortcut the process of a successful conviction, was seldom used. While several pairs 'opened' the book, only one (D&C) bothered to read its contents in any depth. In their case, doing so enabled them to match the missing blood type to the suspect line-up, thereby narrowing considerably the range of possible candidates. Reactions from others who accessed the book suggested a reluctance to engage with the pages of text it contained. Instead, they preferred to persevere with revisiting the video/graphical and audio information until they had gathered sufficient evidence to make a reasonable deduction. The general tendency of

students to ignore large bodies of text was also reflected in their interactions with the second object, 'Finish the Story: Bushfire'.

The 'Bushfire' object was of a completely different design to 'Catch the Thief' and intended to serve a different purpose. In place of the menu-driven interface, 'Bushfire' followed a linear pathway that the students couldn't change. While the time pairs spent on each component of the object varied, their pathway through them didn't, as this was set by the object itself. Perhaps not unexpectedly, the introductory maze activity stimulated the most student enthusiasm, although its relevance to the learning purpose of the object was unclear. For some pairs (e.g., D&C) navigating the maze consumed the most time of all the object's components due to their poor driving skills. Upon completing the maze students arrived at the editor's office and were verbally briefed on their task of improving a bushfire story through the use of different parts of speech. These included using pronouns, adverbs and saying verbs, and adding a dramatic beginning and ending to the pre-written story. Of the six pairs graphed, only two initially spent enough time listening to the editor's instructions to understand what was required (see Table 4, P&A and J&K, 'In the editor's office'). The others visited the editor for no more than a few seconds after realising they could not progress to the next screen until they did so. As students were required to revisit the editor's office to get the next series of instructions after completing each part of the assignment, this pattern of interaction was repeated, although as can be seen by the timeline, the duration of visits diminished rapidly towards the end.

The primary means of engaging with content in this object was via option selections from pull-down menus. With the exception of selecting and editing a dramatic ending (Table 4, 'Selecting a dramatic ending' and 'Completing the story ending') and the cover selection and title task ('Completing cover and title'), students were able to select from a range of provided options for replacing the parts of speech. As recorded on the graphs, generally student thinking level ratings spiked at four and above on components of the object that required them to debate, negotiate and develop content for themselves, rather than simply respond to a series of options the object offered. While the quality of the content they generated was at best variable, evidence was recorded of thinking, indicating at least some level of deliberation in their decision-making. Examples of this are recorded in the 'Selecting a dramatic ending', 'Completing story ending' and 'Cover and title' cells in Table 4.

However, it would be fair to conclude that other components of the object did not attract the same level of thought or deliberation. Preceding each task was a short tutorial provided by the editor that introduced the part of speech the exercises that followed would explore (e.g., 'About pronouns'). The content of these text-heavy windows with audio overlay was largely ignored by all pairs, but they were obliged to at least visit them as the object locked until they did. For most pairs interaction with these tutorials comprised an 'entry and exit click' lasting no more than a couple of seconds (for this reason, this has been included as part of the 'In the editor's office' code). Once they had negotiated the tutorial, the object presented them with windows similar to that in 'Completing the saying verbs' (Table 4), where they could select from an array of parts of speech options to improve their story. Interestingly, despite ignoring the tutorial, three of the six pairs initially made some effort to work out the most appropriate response from the list of options (e.g., J&D—pronouns, saying verbs; P&A—pronouns), although for two of these this effort was short-lived. Only one pair (J&D) showed any level of persistence by making anything more than a token effort to work out best options for each

exercise. As illustrated by the excerpts in Table 4, by far the most prevalent strategy applied was guessing or process of elimination. As each replaceable word had only three alternative options, it did not take pairs long to discover which one was correct, meaning they could then progress to the next screen. With the measured exception of J&D, this process gathered momentum as the pairs worked through the other examples, as they became increasingly disengaged with the heavy text content and repetitive structure. For two pairs, interaction with the object became almost game-like towards the end (J&K and P&A—saying verbs).

Examining the graph for 'Bushfire' reveals a predominance of lower level thinking (recall/remembering and understanding). This is consistent with recorded discourse, and reflects the inflexible way students were required to interact with the object. Generally, they were locked into a *passive response mode* by the design, structure and content of the object—needing only to comply with the object's linear design in a way that somehow satisfied its requirements. How they did this varied little. As the object's design followed a predictable pattern, the students knew how to respond to each screen before they actually got there, and with the exception of J&D, they spent little or no time reading the story to contextualise their word selection. All they needed to do was simply work their way down the list until the correct word was discovered (e.g., Table 4: 'In the editor's office: Completing the saying verbs' task). The object placed no parameters around how often they could guess, and made no suggestion to read the surrounding text to determine more accurately a correct response, if errors were made. The text-heavy presentation and relatively unstimulating nature of content, combined with the response characteristic described above, meant it was easy for students to disengage cognitively with this object while still progressing towards its conclusion—which they appeared very keen to do. The only pair who displayed any level of cognitive fortitude was J&D. At times they seemed prepared to make a genuine effort to work out the best solution (eg., Table 4: 'Dramatic ending' & 'Completing the saying verbs'), while at other times they too appeared disengaged (eg., Table 4: 'In the editor's office'). Overall, however, it was clear from students' responses to this object that it was quite ineffective in delivering its intended goal of teaching about parts of speech.

While it would be tempting to dismiss 'Bushfire' and perhaps objects of similar purpose and structure, it must be remembered that it was purposely designed for a focused learning outcome—and that outcome was *specific knowledge* of parts of speech. In some ways its quite closed design 'funnelled' learners towards a predetermined outcome consistent with its objective but delivered it in a way that really required little cognitive engagement on their behalf—if they chose not to. Apart from purpose, a stark difference between this object and 'Catch the Thief' was its lack of cognitive challenge presented in a way that engaged the students. Put simply, students didn't have to *really think* to achieve a successful outcome, and even in those small parts where they could be creative in generating their own content (the ending and cover and title), most displayed little more than token interest, as judged by the nature of their contributions and recorded discourse.

Summary and conclusion

Some may criticise this study by perhaps accusing it of trying to compare apples with oranges. However, it is not its intention to do so. The study's primary purpose was to identify features of object

design that stimulated different forms and levels of thinking, and to draw some implications from this for teachers' use of objects for different learning purposes. Acknowledging limitations such as object and student numbers and selection, it does offer significant insights into how differently designed objects serve different learning purposes (some better than others), and how teachers need to be mindful of these in making smarter choices about object selection and use.

The study yielded visible evidence that if the design, structure and content of objects did not engage students by demanding their thoughtful and active participation to meet interesting and stimulating challenges, their learning value quickly diminished. This had a lot to do with how the object *interpreted an approach* to achieving its goal, as reflected in its structure and embedded features. Features such as the open-ended challenges associated with collating evidence for the prosecution dossier or synthesising data from different sources in the detective's notebook in 'Catch the Thief' naturally demanded thinking of a higher order than, for example, the relatively closed task of selecting an appropriate adverb or pronoun from a list, as in 'Bushfire'.

Regardless, in reviewing the SnagIt data the inescapable impression was that 'Bushfire' could have done a lot more to engage students had it adopted a more open-ended, perhaps less linear and behaviourist/rote-oriented design. It was apparent from the outset that its text-heavy, formulaic and pre-determined design effectively 'turned kids off' after the maze task (which, incidentally, appeared to have little to do with the object's learning goal). There was little challenge for students, and they had no choice or control in how they interacted with the content. They were merely required to respond on cue when prompted, and they could do this reasonably successfully without having to give it much thought. There were also no interaction parameters or learning scaffolds built into the object that could limit student guessing or systems present to detect when this was happening and offer advice or guidance.

The study suggests *digitally smart* teachers should pay close attention when choosing learning objects to ensure that their structure, design and interpretation of how learning concepts are best developed (i.e., pedagogical elements)—and not simply their learning focus—will adequately support their students' learning goals. It shows that simply placing students in front of a screen and assuming learning will occur, without due consideration being given to how the digital content they are interacting with is presented to them—and whether this will thoughtfully engage them or not, is flawed. Teachers would be well advised to think very carefully about pedagogical assumptions embedded in objects, in making smart decisions about their use with students.

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Appendix A

The list of digital learning objects and URLs accessed by the class

Space Rescue: Planet Thor (TLF L390) (http://www.tbc.school.nz/elearning/localsites/Belts/datas/LV5868/li_001_qantm_001_release/index.html)

Finish the Story: Bushfire (TLF L 1275) (http://streaming.lawley.wa.edu.au/students/TLF/DVD/los/L1275/index.html)

Catch a Thief: Level 1 (TLF L387) (http://www.tbc.school.nz/elearning/localsites/Belts/datas/LV5761/li_001_qantm_004_release/index.html)

Catch a Thief: Level 2 (TLF L388) (http://www.tbc.school.nz/elearning/localsites/Belts/datas/LV5764/li_001_qantm_005_release/index.html)

Celebrity Garbage: Zac Bronski (TLF L1703 (http://splash.abc.net.au/res/i/L1703/index.html)

Celebrity Garbage: Cal Cavino (TLF L1175) (http://splash.abc.net.au/res/i/L1175/index.html)

Show and Tell: Here Boy! (TLF L1280) (http://splash.abc.net.au/res/i/L1280/index.html)

Show and Tell: Eerie Encounter (TLF L1281) (http://splash.abc.net.au/res/i/L1281/index.html)

Timeline: Nhu Minh's Story (TLF L 1282) (http://streaming.lawley.wa.edu.au/students/TLF/DVD/los/L1282/)

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