

How Might the Use of Apps Influence Students' Learning Experiences? Exploring a Socio-Technological Assemblage

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In this paper, we report on primary-school students' views of their learning experiences when they engaged with mathematical phenomena through apps. The students commented on how they used a range of digital tools within the apps to solve problems, and we consider how the affordances of the mobile technologies, including multi-representation, dynamic and haptic, might influence the learning experiences. In particular, we focus on the interplay between the affordances of the mobile technologies with other social and pedagogical aspects, and ask how the assemblage of social and technological entities might influence mathematical learning experiences.

Mobile technologies (MT) populate our social and occupational landscapes. Their presence is ubiquitous, including in educative settings. Their low instrumentation and ease of operation, coupled with the interaction being focused primarily on touch and visual elements, make using them intuitive for learners. Synonymous with MT in educative settings is the use of educational apps. These vary in quality regarding their mathematical and pedagogical approach (Larkin, 2015), evoking questions regarding the appropriateness of the content and pedagogical approaches of some apps (e.g., Philip & Garcia, 2014). However, if MT are a relatively enduring element in mathematics classrooms, their potential to enhance mathematical learning requires examination. Previous research has suggested that the affordances of digital technologies, including MT, have the potential for offering fresh approaches to engage with mathematical concepts and processes, and for re-imagining various aspects of mathematics education (e.g., Borba & Villareal, 2005; Calder, 2011).

In this paper, we explore this potential by examining students' views on the use of iPad apps, as an example of MT, and we consider how affordances inter-relate with other entities, both social and technical. We present data from a larger study on the use of iPads, in two primary school settings. The aim of the project was to engage in a co-inquiry with teachers into the ways apps might enhance student learning in mathematics. Through discussion with the teachers, a question arose in relation to the use of screen-casting to record calculation strategies, and how the affordances of the iPad app might have presented an alternative learning experience to the use of pen and paper. It was suggested that, in order to examine the learning experience provided by the iPad, we needed to look further at the inter-relationships between the learner and the digital medium through an assemblage of entities, in particular the social and technical entities involved in a learning experience. The question examined in this paper was: How might the assemblage of social and technical entities influence the learning process?

Affordances

Building on the notion of affordance as the inter-relationships between the learner and the environment (Gibson, 1977) or the user and the artefact (Brown, 2005), we acknowledge how the digital medium exerts influence on the students' approach, whilst the students' existing knowledge guides the use of the technology. The students' engagement

with the pedagogical media is influenced by the actual digital medium, but this in turn also influences the medium (Hoyles & Noss, 2003), and hence the learning experience is fashioned in distinctive ways. For example, one affordance frequently associated with digital environments is the aspect of multiple representations. The ability to link and explore visual, symbolic, and numerical representations simultaneously in a dynamic way has been recognised extensively in research (e.g., Ainsworth, Bibby, & Wood, 1998; Calder, 2011). Apps that enable screen-casting, the digital recording of the computer screen, along with voice recording, introduce a further modal affordance in creating an aural representation to which students can listen. It allows students to record individual or group presentations of mathematical processes, strategies, and solutions.

Research has further shown that iPads and apps foster experimentation allowing space for students to explore (Calder & Campbell, 2016). The apps' affordances of interactivity and instantaneous feedback foster the learners' willingness to take risks with their learning (Calder & Campbell, 2016). Other researchers contend that the affordances of digital technologies, coupled with the associated dialogue and social interaction, may facilitate students learning to pose problems and create explanations of their own (Sandholtz, Ringstaff, & Dwyer, 1997). They allow students to model in a dynamic, reflective way with other learners, mediating the language evoked through interaction with each other, the digital media, and the mathematical ideas, and hence influencing the learning experience (e.g., Calder, 2011).

Therefore, a theoretical perspective that acknowledges the inter-relationship of the multi-modal representations of the iPad with the learner, along with the mathematics and social interaction with others, could help to draw these entities together and help to understand how the use of iPads might influence the learning experience in primary mathematics classrooms.

Socio-Technological Assemblages

Delanda's (2006) assemblage theory explored how inter-relationships are merged to form a social complexity. The social complexity as a whole emerges from heterogeneous parts, and the properties of the whole emerge from the interaction between the parts. We relate Delanda's notion of assemblage with other theoretical perspectives suggestive of collectives. For example, Borba and Villarreal's (2005) perspective saw understanding emerging from the reconciliation of re-engagements of the collectives of learners, media, and environmental aspects with the mathematical phenomena. Borba and Villarreal contend that as each engagement re-organises the mathematical thinking and initiates a fresh perspective, it in turn transforms the nature of each subsequent interaction with the task. The digital media influence the engagement and ensuing dialogue in particular ways, which, with self-reflection or further dialogue with others, transform the learners' perspective (Borba & Villarreal, 2005). The learners then re-engage with the task from this new perspective. This iterative process continues until some form of shared negotiated understanding occurs (Calder, 2011).

From both Delanda's (2006) and Borba and Villarreal's (2005) perspectives, the whole, or in the case of this paper the learning experience, becomes the articulation of discursive and non-discursive elements of objects and actions (Delanda, 2006). However, a key distinction is Delanda's proposal that all entities and relationships, whether social or non-social, are ontologically and epistemologically indistinct. As such, knowing or understanding within the learning experience is no longer a means of representing or reflecting on new knowledge, but one of interacting with and creating new knowledge.

Delanda's philosophy proposed that social and non-social are ontologically indistinct; they are both composed of assemblages. Social assemblages may be codified through language, whereas non-social or technical may not. However, the very use of the technical can be seen as expression, and this is illustrated through the multi-representational and multi-modal affordances of the iPad. The learner may select representations as a way of expressing and creating knowledge; the learner may also use hand actions with the touch interface of the iPad screen, again as a way of expressing and creating knowledge.

Despite philosophical distinctions, these two perspectives of merging learners with digital media within a situated learning experience point to the notion of an assemblage of digital and social elements, which we term a socio-technological assemblage. In this paper, we report on students' perceptions of the use of several mathematics apps and investigate how the students perceived the learning opportunities presented by the apps. The students' perceptions are then analysed in relation to the notions of affordances and to the notion of socio-technological assemblages, in order to investigate the influence of the iPad, as an example of MT, on learning experiences.

Methodology

In the research for the larger two-year project, we used an interpretive methodology related to the building of knowledge and the development of research capability through collaborative analysis and critical reflection of classroom practice and student learning. The research design was aligned with teacher and researcher co-inquiry, whereby the university researchers and practicing teachers work as co-inquirers and co-learners (Hennessy, 2014). In the first year of the project, three teachers, all experienced with using MT in their programmes, were involved in the study. The schools were situated in a provincial city. One teacher taught a Year 4 class (7- and 8-year-olds) in a school that used a bring your own device (BYOD) approach, while the other two teachers team-taught in a combined Year 5 and 6 class (9- to 11-year-olds) in a school with one to one provision of iPads (80 students in total). Data, obtained through different sources (focus group interviews, classroom observations, interviews with teachers, and blogs), were analysed using *NVivo* via a mainly inductive or grounded method to identify themes. While the researchers identified the initial themes and codes, refinement occurred through joint critical reflection between teacher practitioners and academic researchers in research meetings. Two themes that were focused on in the research meetings were affordances and socio-technological assemblages.

In this paper, we present data from student focus group interviews and individual blogs in order to investigate the students' views in relation to their learning, and to explore how the two notions, affordances and socio-technological assemblages, may help to examine how the use of iPads have influenced the students' interactions with mathematical ideas. The student blogs were obtained partway through the first year of the project. Focus group interviews with the students were conducted at the beginning and end of the years. Prompts were given to support students in writing their blogs, and semi-structured interview schedules were developed for group interviews with six students from each class.

Results and Analysis

Student Blogs

In the student blog data, references were made to the features and affordances of the apps and iPads, how these influenced the learning experience, and the ways understanding might emerge. Several blog entries referred to the multimodal affordances of screen-casting.

You can record your learning and you can see what stage you are working on and instead of writing in our book we can just record our voices and upload it to Google classroom!

It helped to solve my problems - by using Explain Everything you can record and pause and think about what you're saying.

The ability to record, review, and then edit also engendered confidence, hence the affordance of the app to encourage risk-taking and exploration.

I can confidently record my voice and... [I] feel okay with others hearing my recordings.

The visual dynamic representational affordance was suggested with students using *Hopscotch* and *Multiplier* apps:

Hopscotch is a big hit, as you can see your creations moving around.

Multiplier helps me because it shows what it looks like so I know how to do it.

The use of the *Multiplier* app also illustrated the haptic affordance, as the students used their fingers to draw out the matrix and had both visual (including colour coding) and numeric representations simultaneously linked together. It was a multi-levelled problem-solving environment with a tap used during the experimentation and review stages:

You tap on which one you think is correct.

The haptic affordance was mentioned in other blogs:

I like to touch things [and move them] and: You could draw over the answer.

The use of programming apps with Sphero robots made strong physical and visual connections too, especially in geometry. At times, the connection between hand movements and movement of the Sphero (small robots) was mediated by the app.

Tickle helped me programme robots to draw triangles.

We used this app (Tickle) to learn about making shapes, angles, and vertices.

Students made further comments related to a mixed use of pedagogical media. For example, the students were comfortable moving between their iPad and more traditional media

I can still switch back to my book easy and it's still easy to use apps.

Key viewpoints from the student blogs referred to the dynamic multi-modal representations, hand actions and the haptic, risk taking, and exploration. Students also referred to mediation through programming and the use of different pedagogical media.

Student Interviews

These key viewpoints were reiterated in the student interviews, both at the beginning and end of the year, but the students' responses also extended their perspectives. Students again referred to drawing on the iPad screens or of tapping to select a tool, hence

indicating the haptic affordance of the iPad. In addition, they commented on how the iPad made their work “easier and tidier.”

Again the use of screen-casting to record their solution strategies was a key feature. The students talked of video-recording themselves doing maths, and recording their working. As one said,

It’s just like making a movie for maths.

Hence, students were indicating the multi-modal representational affordances of the screen-casting app. The opportunity to record their voices whilst writing and drawing seemed important. One student commented that it was

hard to explain without writing down. You can write it down as well as explaining it while you’re recording.

The use of multiple modes simultaneously supported this student in expressing his thinking. The opportunity to pause and edit recordings also appeared to be significant in supporting students in expressing their thinking.

The cool thing is that you can actually pause it and then think about what you’re going to do.

Students also commented on the assurance that they had a correct solution, and hence had confidence in their strategies to start recording. Others referred to the opportunity to use the different visual and dynamic representations on the iPad and how these introduced them to new strategies.

I like learning new strategies, using a number line and place value.

I learnt how to use the reversing strategy on the number line.

Students also referred to opportunities for collaboration with their peers and how they worked on a mathematical idea together.

I like working with my friends and then recording our voices like working out an equation together.

Working in a group helps us work independently a bit more because when it’s in a group they’re all giving us ideas.

The opportunity to share documents was also seen as a way of collaborating.

You can share docs with someone – so you can tap on the same thing, so you get ideas quicker.

Collaboration also provided the opportunity to explore and experiment with mathematical ideas

Luke asks me to work with him because we like to help each other out and solve things – so if we don’t get something, we try and work it out.

The responses from students in the interviews suggested further viewpoints in relation to the use of multiple modes in expressing and creating their thinking, visual and dynamic images in learning key concepts, and peer collaboration in sharing ideas and in exploring or working out new knowledge.

Discussion

Student responses in the interviews and blogs acknowledged the potential of the iPad in manipulating objects dynamically on-screen. Students spoke of acting directly with the object and referred to tapping or drawing on the screen. The screen-casting feature was seen to introduce multiple modes and representations as students worked simultaneously with dynamic visual recordings (drawing, manipulating digital tools, and writing symbols

and words), along with speech, to create a dynamic aural-visual representation. The coding apps *Hopscotch* and *Tickle* were used to connect numeric and symbolic representations in the coding with the physical movements of the Sphero and the creation of geometric shapes. Although the movements were mediated by the coding process, the students commented on the connections between the movements and their learning. Furthermore, the students referred to collaborative working with their peers. They indicated how ideas could be shared and worked on together. The students also mentioned how non-digital and digital technologies were used together.

In sum, student comments were suggestive of inter-relationships between the multi-modal affordances of the iPad, along with other non-digital entities including peer interaction and other pedagogical media. These inter-relationships are interpreted through the notion of an assemblage, where social and non-social become merged.

In relation to Delanda's (2006) assemblage theory, the learning experience is viewed as a social complexity constituted of heterogeneous entities. Students' comments were suggestive of social assemblages such as the use of verbal language when communicating with each other or voice recording. However, students also communicated through tapping on the screen or in sharing a document. Students also referred to use of hand actions when using *Multiplier* or *Tickle*. As such, the technical materiality, that is, the multi-modal affordances of the iPad, were used by the students to communicate and express ideas. Social and non-social could be seen to merge in line with Delanda's theory, and the learning experience became a means of interacting with and creating new knowledge in ways that were determined by the features of the iPad as well as through other media and communication.

Borba and Villarreal's (2005) perspective focused on engagement within a collective of learners, media, and the environment. Engagement re-organises thinking and provides fresh perspectives for re-engagement. The students suggested opportunities to interact in collaborative ways to "work it out" and experiment. The students had opportunities to pause recordings in order to reflect before engaging further with the media. In order to interact with the mathematical ideas, the students drew on existing knowledge and affective dispositions to engage with the mathematical ideas, not just through the iPad, but also through a range of social interactions that evoked interpretations or understandings that were negotiated further (Calder, 2011). Not only did the students note the recordings as a way to show their thinking processes in solving a word problem, it appeared that through pausing and editing, the students took time in preparing and perfecting their recordings. They were able to reflect on what had been said, and think about what to say next. Here the students were influenced by the iPad which they then influenced.

From both theoretical perspectives, the multimodal affordances of the iPad can be seen to provide new entities for social and technical to merge as an assemblage or a collective within a learning experience. So, in answer to our initial query about the use of the iPad to record a strategy, we would suggest that when viewed as a separate entity, pen and paper would seem to provide a similar experience to a written recording on the iPad screen. However, when taken within the entire learning experience, in this case creating a screen cast, there are opportunities for social and technical entities to merge in a way that would not be similar to a pen and paper activity. The content and nature of the screen-casting recordings were seen to merge the multiple modes of verbal expressions with drawings and symbols. Students created their own ways of expressing their knowledge. Furthermore, some students developed these recordings collaboratively and acknowledged opportunities that enabled them to share and negotiate their knowledge in conjunction with the multi-

modal affordances. Such recordings, compiled individually or collaboratively, would seem to illustrate the notion of a socio-technological assemblage that may influence the perspectives of those who viewed them, as well as those who created them.

Conclusions

Previous research has suggested that MT offer affordances that can reshape the learning experience. In this paper, we aimed to consider how learning mathematics through apps might influence learning experiences by examining students' views in relation to the idea of a socio-technological assemblage. The idea of an assemblage suggests that the same mathematical phenomena can evoke different ranges of social and technical entities when approached through alternative pedagogical media, and so the resulting learning experiences, constituted by the merging of these different ranges of social and technical entities, will differ. The entities explored in this paper were drawn from the students' comments. These acknowledged the process of verbalisation, along with the manipulation of images, drawing, and other representations, and would suggest a new learning experience: an experience situated within an assemblage of inter-related social and technological influences. Further study of the use of MT from an assemblage perspective could help us understand these influences and, consequently, to develop the use of MT to enhance learning.

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