

# Facilitator, Functionary, Friend or Foe? Studying the Role of iPads within Learning Activities Across a School Year

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## ABSTRACT

We present the findings from a longitudinal study of iPad use in a Primary school classroom. While tablet devices have found their way into classroom environments, we still lack in-depth and long-term studies of how they integrate into everyday classroom activities. Our findings illustrate in-classroom tablet use and the broad range of learning activities in subjects such as maths, languages, social sciences, and even physical education. Our observations expand current models on teaching and learning supported by tablet technology. Our findings are child-centred, focusing on three different roles that tablets can play as part of learning activities: Friend, Functionary, and Facilitator. This new perspective on in-classroom tablet use can facilitate critical discussions around the integration and impact of these devices in the educational context, from a design and educational point of view.

## Author Keywords

Young children; tablets; classrooms; evaluation; education

## ACM Classification Keywords

H.5.1. User Interfaces (e.g. HCI): evaluation/methodology

## INTRODUCTION

Teaching environments and learning approaches are constantly evolving to reflect change and development in society. The advent of low-cost digital computing has given rise to technological innovations aimed at enhancing the classroom experience. These have included the integration of computers [51, 58] and smartboards [22] into the classroom, as well as, more recently, the in-class use of tablet technology [21, 49]. Technology-supported learning has long been a source of debate. Early innovations in computing technology inspired Papert to muse that “*children can learn to use computers in a masterful way and that learning to use computers can change the way they learn everything else.*” [43, p.8]. More recently, Prensky highlights the need for children to learn “*Digital Wisdom*” in today’s digitally enhanced world [45].

The adoption of new technologies in schools, especially the iPad, has received an enthusiastic reception across schools in the western world [2, 6, 21, 24, 52]. In 2014, more than



Figure 1. We observed iPad use during classroom activities.

70% of UK schools used tablets and almost 10% had initiated a one-tablet-per-child policy [9]. While we see similar adoption rates in the US [38], a recent report suggests that tablets may not be suitable for use in classrooms, and that schools are moving away from iPads as they are a little “*too fun*” for use in educational environments [37]. Although the integration of tablet technologies in classrooms has already begun, questions of how to design suitable software systems that meet the needs of children and teachers are still under-explored. Addressing this issue requires multiple lines of inquiry including systematic and long-term studies involving children, educators and policy makers.

In our work we aim at classifying classroom activities employing the iPad to investigate the role that tablet technology can play in the classroom. Our long-term study in a classroom illustrates the impact of iPads on children’s creativity, competency and intrinsic motivation to learning. We found that iPads can take on a range of roles as part of learning activities, including Friend, Functionary and Facilitator. We suggest these child-centric considerations that expand on previous technology-centric models lay the foundation for future work on designing tablet-based systems for learning activities and can be used to facilitate future studies of this type of technology in curriculum development.

## RELATED WORK

Much has been written about the integration of modern technology into educational environments and how this effects learning [4, 56, 45]. There are many roles technology can take on within a classroom. For example, it can be used to facilitate access to information (typically using the internet) [14], to support writing and calculation (e.g., through tools such as MS Word Excel) [36], or to explore scientific phenomena through simulation [35]. However, it is the wireless capability of tablet devices that can potentially transform education allowing what Norris and Soloway refer to as “*the age of mobilism*” [39]. We first present previous research focused on in-classroom tablet use and then provide an overview of current models for technology use in school.

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## Tablets in the Classroom

While previous studies have found that the introduction of computer technologies has not had a significant impact on children's learning [22], research suggests that the provision of personal devices, such as tablets, shows greater impact on pupil engagement [21]. However, the implementation of classroom technologies is often associated with complex practices and increased workload in order to orchestrate classroom activities [7, 25, 46].

The use of tablets as part of teaching is challenged by the need to integrate general software into classroom activities (for example, they often rely on iTunes as a platform for delivery), and the educational value of the apps [12, 28]. Additionally, studies have shown tablets' distracting effect on children's behaviour in class [13]. That being said, tablets can also positively influence children's behaviour towards learning increasing, for example, engagement in certain exercises [21, 30]. Furthermore, access to the tablet as a personal device and the ability to take it home, has been found key to children's adoption of the technology [5, 6, 12].

Findings from studies comparing children's learning activities with iPads and with traditional learning material (e.g., using a history app [18]) provide valuable insights into the impact of tablet technology on learning [1, 15, 31, 40]. However, this study approach does not shed light on tablets' integration into diverse classroom activities as they evolve ad-hoc. Other studies that included large groups of children in classroom environments highlight organisational and group work problems around tablet-use [31, 40]. Further research stresses the need to study these devices in-situ, within the context of use [31] (an already known challenge in HCI [20]). Our study builds on this previous work by observing the introduction and gradual integration of iPads into a classroom over a period of several months. Our observations cover iPad use in a variety of learning scenarios, enabling us to document how the classroom environment and children's experience changed and adapted to this technology over time.

## Technology and Transformative Learning

Previous research has looked at the impact of technology on learning in a systematic way [29, 47]. McCormick and Scrimshaw's model for technology use in schools takes on an educational perspective and classifies three levels of impact: technology used for *efficiency*, as a means to *extend* existing learning, allowing *transformative* learning that is not possible without the device [29]. The *SAMR* model proposed by [47], classifies the use of technology as a means of either enhancing learning through *substitution* and *augmentation* or through *modification* and *redefinition* of learning practices. However, this model was developed and framed from an industrial perspective to support the roll-out of products to educational environments. While presumably based on practical findings, neither of these models exemplify how the identified categories manifest in modern classrooms. Educational researchers have applied these models to in-classroom iPad use, transforming them to classify learning behaviours around this technology as either *enhancing* (efficiency, substitution and augmentation) or *transformational* (extension, transformative, modification and redefinition) [5].

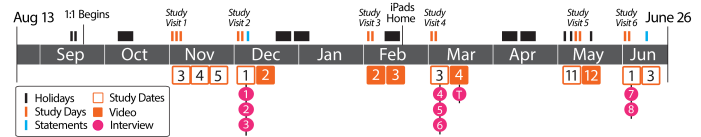


Figure 2. A timeline showing study visits across the school year.

We expand on these findings by investigating not only the role of iPads regarding enhanced and transformative learning, but also within the classroom ecology. We provide in-depth examples of classroom activities with the iPad in different subject contexts and define a nomenclature around these use cases, introducing the terms Friend (or Foe), Functionary and Facilitator for a rich classification of in-classroom iPad use.

## STUDY SETUP & METHODOLOGY

In our study, we observed a class as they adapted to a one-child-per-iPad programme. The study was conducted over eight months in a Scottish school with a composite, mixed-ability Primary 6/7 class (age 10–12), where the iPads had just been introduced into the curriculum. The class consisted of 22 children (9 boys), and each child was provided with an iPad Air 2. For the first four months of the study, children only had access to the iPads in school; after this they were allowed to take them home. Children were responsible for maintaining the iPad case and charging equipment but were not allowed to install apps themselves. The teacher was responsible for children's choosing and installing apps to meet the curricular expectations, occasionally downloading apps she felt particular children would benefit from. The range of apps increased throughout the school year, as children were introduced to new functionalities of the iPad.

During the study, a researcher visited the classroom six times for two to three subsequent days and, following an ethnographic approach [11, 19, 57], observed and documented (via notes and video) all activities in class. In addition, interviews with pupils and the teacher were conducted to elicit first-hand information about their experiences with the iPads in school and at home. Consent for the study was obtained from the children and their parents, the teacher, the school, the local authority and our university. A timeline outlining our visits, observations and interview dates is shown in Figure 2. A typical school day runs from 9am to 3:15pm. To minimise disruption, our observations were organised around school holidays and special events and activities. On three occasions, due to school commitments, observations ceased at lunchtime.

Typical of a UK classroom, the classroom layout is dominated with clusters of tables for 4–6 pupils each (see Fig. 1 & Fig. 3, left). A smart board was located at the front of the classroom with open floor space where the children would often sit during whole-class activities (see Fig. 3, right). No changes were made to the classroom layout for the study.

## Data Collection & Analysis

Throughout each study visit, study data was collected in the form of observational notes and video recordings and photographs of classroom activities. In addition, interviews with the children and the teacher were video recorded, and brief essays written by children about their experiences with the iPad were collected at the beginning and end of the study period.



**Figure 3.** Video cameras (circled) captured activities at a group table (left). The class often gathered in front of the SMART board (right).

#### *Observational Notes & Photographs.*

In order to capture the range of classroom activities as they took place throughout each study day, observational notes were taken continuously to capture coarse-grained information. These notes were then transcribed into spreadsheets and structured into 5 minute blocks. This resulted in a rich documentation of daily classroom activities, the role of the iPad as part of these and number of children they involved (individual child, small group of 2–4 children, large group of 5–8 children, or the entire class). This collating of observational notes provided a means to quantify activities in the classroom.

Observational notes were enhanced by photographs which captured instances of iPad uses in the context of different subjects and learning activities. Photographs were annotated and collated following each visit. In general, the observational notes and photographs were used to investigate iPad use in the larger context of the classroom.

#### *Video Recordings*

During five of the six study visits (see Fig. 2), two video cameras were installed in the classroom to capture activities around a particular classroom table from two different perspectives (see Fig. 3, left). A total of approx. 37 hours of video data was captured that focuses on a particular group of students, providing a fine-grained view of classroom activities. All video footage was first catalogued with summaries of activity episodes. To create a qualitative coding scheme, we then analysed video episodes alongside our observational notes, coding for particular iPad uses as part of different subjects, learning activities and group constellations. This process was conducted by one researcher and iteratively refined as a result of in-depth discussions with three additional researchers. The video data complements the more coarse-grained nature of observational notes and photographs.

#### *Interviews with Children and the Teacher*

16 children volunteered to be interviewed about their use and experience of the iPad in class and at home. Interviews took place in a quiet room, separate from the classroom. Children were interviewed in pairs to put them at ease. Interviews followed semi-structured questions and provided an opportunity for children to show some of their work on the iPad. We ask them about the apps they used at school and at home, which apps they liked or disliked and how they experienced the iPad. Additionally, we conducted a semi-structured interview with the class teacher to gain insights into how she felt the iPad impacted class work. Questions included the teacher's opinion on the role of the iPad in the classroom, its advantages and disadvantages as part of activities, how the classroom at-



**Figure 4.** Different uses of the iPad as a *Functionary*.

mosphere had changed since the introduction of the iPad, and its benefits for the teacher and children. Interviews were conducted across the study period (see Fig. 2). Approx. 130 min. of interview data was recorded, transcribed and qualitatively coded using the scheme derived during video analysis.

#### *Written Opinion Statements by Children*

At the beginning and end of the study (see Fig. 2), the children were asked through their teacher to briefly describe their experience of the iPad to that point in written form, that is, what they liked and disliked about it. In total we received 26 written half to one-page long essays in typed form (15 from the beginning and 11 from the end of the study). Again, children's statements were qualitatively coded.

A number of apps were used during our study, and we name some of them as part of our description of iPad-centred activities. It is clear that the experience of the iPad is not only influenced by its form factor and interactive capabilities but also by the visual and interaction design of a particular app. However, in this study we focus on how the iPad was used and experienced as an interactive device during particular classroom activities—while we report on general apps and features that were relevant for these experiences, we do not explicitly distinguish between tablet- or app-specific functionalities.

Based on this analysis our findings show how iPads were incorporated into daily classroom activities and how the roles that these devices performed as part of these activities.

## **FINDINGS**

We first provide a general overview of iPad use in the classroom and then highlight how the iPad was integrated into different in-class activities, followed by our analysis of the role of the iPad in the classroom.

### **Forgotten: Activities Taking Place without an iPad**

The majority (56.6%<sup>1</sup>) of all observed class activities did not include the iPad. During these times that we classify as *Forgotten*, the iPad was turned off or not in use. We did not find

<sup>1</sup>All % were derived from counting the frequency of activities we captured via observational notes.



a relationship between the absence of iPad use and the subject area, but our observations indicate that, typically, the iPad was not included in large group activities or exercises involving the entire class; children mostly used it individually or in small groups (2–4 children).

### Focus: Introducing Skills around iPad Use

4.1% of classroom activities were centred around the functionality of the iPad. In these instances, sometimes unintentionally, the iPad became the *Focus* of the lesson, for example, when the teacher taught the class how to use iMovie on the iPad. Typically, in instances like this the class gathered around the SMART Board as the teacher demonstrated the required steps, before children attempted this individually on their own iPads (see Fig. 3 left).

There were also instances of *unintentional Focus* when the iPads were not working as intended, and the teacher and pupils had to troubleshoot or resolve issues. For example, the teacher had instructed the class to download a book, which was then hampered by licence restrictions and slowed down by the book's file size which had a negative impact on the loading processes of all iPads in the class. Instances such as this occurred occasionally and were often resolved by returning toward traditional classroom materials and activities (e.g., working with physical books instead of the iPad).

In the remaining classroom activities (39.3%), the iPad was integrated into exercises, but not the focus of the lesson. It is this ad-hoc use of the iPad, as part of everyday classroom and learning activities, that we are particularly interested in, since these usage examples can show how this type of technology influences classroom activities in general (or not). We first describe the general format of observed learning activities in the classroom and then outline observed instances of iPad use across the curriculum. We next classify the role of these devices based on how they integrated into classroom activities and the kind of activities they facilitated.

### OBSERVED ACTIVITIES IN THE CLASSROOM

Classroom activities involving the iPad included literacy and numeracy exercises, research and preparing presentations—activities that provided opportunities to both learn and demonstrate knowledge. In the following, we outline a range of activities, which included collaborative work and creative thinking, and illustrate these with examples taken from our observations [Obs], statements [Stat], video footage [Vid] and interviews [Int](numbered according to Fig. 2). Names of participants were changed to preserve anonymity.

#### Core Classroom Tasks: Literacy and Numeracy

Core class activities, such as practising literacy and numeracy skills, typically include writing, spelling or maths exercises. These types of exercises were often supported by or conducted on the iPad. For example, children used the iPad to write stories and essays. Our observations and interviews with children and the teacher indicate that the iPad use increased children's engagement and motivation during writing activities. For example, one child stated: *"On Microsoft Word I am really good at my writing, because I used to only write like 200 words on my diaries. And [on the] evacuees story [a particular topic they were focusing on] I have written up to 704 words."* [Kate, Int 6]. Along similar lines the

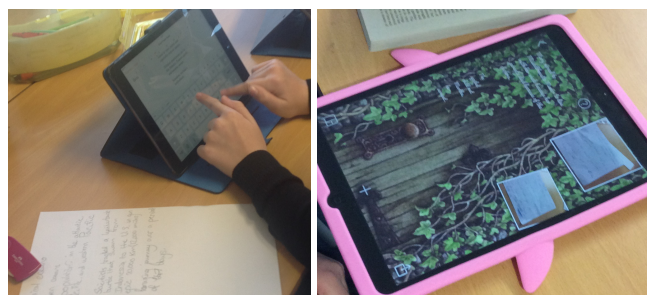


Figure 5. Examples of handwritten notes on the iPad.

teacher explained: *"It's [confidence in writing stories] really increased. In terms of their story writing, you know, they see a page in the jotter as being 'Ugh, I have written a whole page' or 'I have written a page and a half, and I can't believe it.' I would only count that as maybe 200 words. When we are actually doing our story writing on our iPads, they were doing 700 words without realising it. And the 700 words they were writing—it's amazing! And what they were doing on the iPad is that they can do a word count, so they were seeing how much they had written and seeing the improvements. And so they kept trying to beat one another, like, adding to their word count. But when they were adding their word count and trying to beat one another, they were adding descriptions. They were adding extra descriptions about what the character was wearing and the settings. And I am thinking: 'This is absolutely great—this never happens'."* [Teacher, Int T].

In order to improve literacy skills, the teacher regularly set the children spelling exercises. A traditional spelling activity would include learning new words using the "look, cover, write, and check" method. Here, children look at the new words to learn, then cover this list and try to write these words themselves before checking against the list again. The iPad was often used for this type of exercise—sometimes by instruction of the teacher, sometimes by the children's choice—either via a dedicated app (e.g., SuperSpellers [55] or Spelling Superstar [16]), or just a common text editor such as MS Word [34] or Book Creator [3]. In particular, the latter gave children a lot of choices of how to conduct the exercise, e.g., whether or not to type or finger-write a word. Children would also make use of customisation options offered by the text editors, e.g., choosing a particular font or background colour. Digital editors or spelling apps may be advantageous as they promote the sort of engagement that helps children to better remember the spelling of words, as reflected in the following statement *"It's easier to learn with the spelling apps. Much easier. It's more, uhm, it will make us more interested in doing spelling."* [Ann, Int 7]. Future studies are required to investigate if and how tablet apps support "active spelling" [50].

Numeracy activities within the classroom often incorporated the iPad as a substitute for paper (see Fig. 4, top right), using the calculator (see Fig. 4, bottom) or to show supporting materials like maths grids. Children enjoyed using dedicated maths apps on the iPad, such as 'Sumdog' [54] (*"I like to play on Sumdog a lot cause it's fun."* [Stacey, Int 8]), 'Division Wiz' [8] (*"My favourite app for school is Division Wiz."* [Paul, Int 3]) or 'King of Maths' [27] (*"Oh yeah King of Maths is good."* [Kate, Int 6]).



Children appreciated the iPad as an alternative mode of learning. For example, Daisy felt these apps “help her brain. [...] The iPad helps even more because, like, in the apps it shows me what it actually means instead of somebody telling me what it means. Because sometimes when somebody tells me I don’t really understand. Because I have trouble in math cause it’s not really my thing—so that really helps!” [Daisy, Int 8]. The Teacher appreciated that using these apps allowed children to work at a level appropriate to them: “Rather than having to cut out and make three sets of differentiated games for ‘times tables’, you know, one click of a button and it’s there and they differentiated it to suit themselves.” [Int T].

However, children were also aware of the strengths and weaknesses of the iPad for certain tasks. Kate complained that the Pages app was “bad for maths cause when you do maths you have to space it all out and sometimes it goes away over there...”. She knew a more suitable application: “Show Me is better for maths, like, because you can just write with a pen—you can just do the calculation.” [Kate, Int 6].

### Researching Information

Children often used the iPad to find information about particular topics. For example, they would research and extract information about a topic via the iPad’s web browser. As part of these tasks, children captured information both using the iPad as well as traditional tools such as pen and paper. Often, handwritten notes on paper were later transferred into digital form via the iPad, for example, by typing them directly into PowerPoint or Keynote, or by inserting a photograph of their notes into their digital presentation (as shown in Figure 5).

We also observed examples where children exclusively used the iPad for the research exercise using the web browser in combination with digital note-taking apps. In these cases, children frequently switched back and forth proficiently between the browser and the note-taking app.

Our video analysis revealed that some children were quite creative in solving these open-ended research tasks combining the functionalities of different apps in ways that are not immediately apparent. For example, Kate looked for relevant news articles using the web browser (see Fig. 6, (left)) and took a number of screen shots of a news story she found. She then opened up the Book Creator app [3] and pasted these screen shots into a new file, side by side. Finally, she circles particular aspects in the text and digitally annotates the screen shots (see Fig. 6, middle and right). She swiftly and creatively used the iPad to highlight and prepare material she found meaningful for the follow-on task.

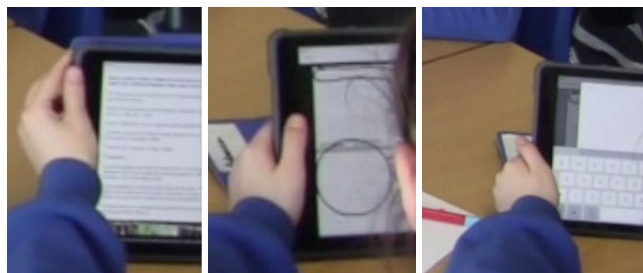


Figure 6. Kate uses a unique approach to collating research [Vid].



Figure 7. Using digital imagery as a reference for a poster [Obs].

### Preparing Presentations

Children are often asked to demonstrate their learned skills or outcomes from particular activities, for example, in the form of posters, presentations or written work. In our classroom, typically, teachers would leave it up to the children to choose the medium in which they would prepare these presentations. We found that children made use of both paper and iPad apps to help them present their results from particular learning activities, sometimes in combination.

Using the iPad to prepare presentations was popular among children as they could take advantage of the device’s digital capabilities, such as ease of editing and deleting: “[With the Pages App] you can write a lot of things, and you can add a lot of photos and change the writing and make flyers. And with Pic Collage you can edit the photos and make posters.” [Sally, Int 5]. Children also used the iPad to search for visual materials, such as images or even fonts, to incorporate into their presentations. That being said, children did not always create their final presentation or poster using the iPad but often used the digital material displayed on the iPad just as a reference to then draw things out on paper. This is illustrated in Figure 7 where a child is creating a poster about ‘Fireworks Safety’. During the interviews children often described their use of the iPad for inspiration: “We get ideas on the iPad of what we can draw.” [Ben, Int 2].

Besides the more flexible editing capabilities of the iPad, children also appreciated that it facilitated accomplishing what they considered to be a more professional look to their presentations or posters, but also that the iPad would allow them to overcome perceived inadequacies in their own artistic skills.

Despite the advantages that many children saw in using the iPad for posters and presentations, children still enjoyed making paper posters. Sally reported that she felt that the iPad could not offer a satisfying drawing experience: “When I do a poster, I like drawing pictures, and I cant really do that on the iPad. I can always draw on the paper and take a picture of it, but it’s not the same thing.” [Sally, Int 5]. Interestingly, she refers to the drawing experience and the quality of the physical drawing that cannot be replicated through digital means.

Our observations also suggest that presentations using physical material can be more easily put on display for others to see. For example, the paper posters on ‘Fireworks Safety’ were hung around the school as soon as they were completed. In contrast, creating physical versions of the digital posters required sending the digital files to the teacher, who would then send them to the school printer. This process was limited by



Figure 8. Children collaborate differently during activities [Vid].

printing costs, teacher's time, access to the printer (which was in another building) and the available paper size and colour.

Poster creation offered a limited means for children to display their knowledge. More in-depth topics usually asked for presentations of learning, usually in Keynote or PowerPoint. One child who felt he had more to say on Fireworks Safety, used Keynote during his free time to make an animated presentation to showcase what he had learned. By the end of our visits, children were accomplished at making such presentations using different apps and incorporating a variety of different fonts, colours, images and animated gifs.

### Collaborative Activities

Structured group activities were sometimes set up in the classroom to promote collaborative work. For example, children worked in small groups to research a news story for later presentation. In these instances we observed different ways in which children would work together using their iPads.

Figure 8 (left) taken from video footage shows Ben and Henry, collaborating on Social Studies research using their iPads. Sitting closely together, they independently research news stories on a web browser. They frequently stop to discuss what they have found and how this can contribute to scripting a presentation. In contrast, other groups researched topics on the web in parallel, without discussing found information items, but gathered afterwards to share their information. For example, after finishing her research task, video footage shows Kate (see Fig. 6) taking her iPad to her group partner to discuss the information she has gathered, and they start to script and practice their presentation.

Some activities that involved the iPad were interwoven with occasional sharing of results. For example, during a maths lesson, video footage captured Ben and Paul solving maths problems from a paper worksheet (see Fig. 8, right). Ben is copying the maths exercise into a text editor on the iPad. Paul does the same, shifting back and forth between the editor and the iPad's calculator app. Ben frequently leans over, presumably, to see how Paul solved the maths problem.

During collaborative activities, children dedicated different iPads for different tasks. Ben explained: *"When we are making presentations we mostly [...] get a partner or a group so we will use one person's iPad to do the presentation and the other person will get their iPad and look up pictures for them to draw."* [Ben, Int 2]. Sometimes tasks were divided between a pair or group and children would take turns performing each role. For example, during a gymnastics lesson children worked in small groups, using the iPad to capture performing a gymnastics move (such as cartwheel, tumble

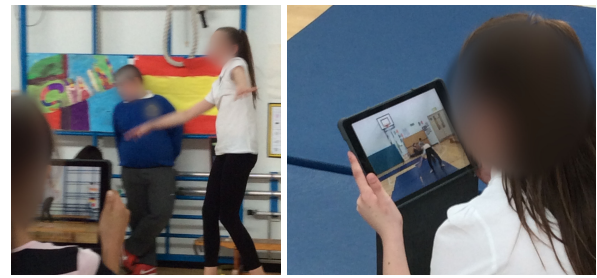


Figure 9. Using the iPad during gymnastics [Obs].

or jump) on video: one child performed the move while the other(s) video recorded it (see Fig. 9, left). The group would then watch and discuss the video to reflect on the performance before repeating the activity or switch roles.

The teacher praised how the iPad improved sharing and collaboration within the classroom, particularly between boys: *"There is quite a lot of boys in that class who are quiet and shy. They don't like interacting except with one another. With the iPad they are talking to one another more and [to] others, because they are saying 'Look at this' or 'Look at what I have done' or 'How did you do that?' or 'How does that work?' So, socially it's helping them."* [Teacher Int T].

### Creative Activities

Our observations and interviews with children indicate that the iPad facilitates in particular creative activities, as evident not only in activities that inherently require some sort of creative approach (e.g., poster creation, making slides for a presentation or creating a video), but also in everyday learning activities. For example, we observed a girl downloading images representing individual letters from the web and assembling these into spelling words, instead of just typing out the word into a text editor. The teacher encouraged this behaviour as a creative approach to the spelling exercise.

As discussed earlier, children used the technical capabilities of the iPad to creatively put together posters or presentations as part of class exercises. For example, halfway through our study, children collaboratively used iMovie to make short videos of their iPad use at school for their families and friends. Children went above and beyond the task and included interviews with classmates, music and special effects to make the videos more expressive and entertaining.

Interestingly, children also engaged in similarly activities during their free time at school and obviously quite enjoyed these. For example, Kate decided to create posters and drawings using her iPad to advertise her dance group. Amy created a collage of a face which was composed of facial features cropped from digital photographs of her friends, and made a trailer about herself and her friends: *"We have got something called iMovie, where you can make little movies and star all your friends in it and stuff."* [Amy, Int 2]. During one interview Bethany commented on how the iPad promotes creative activities *"You get to make some fun photos! You can even change the faces of your friends on that."* [Bethany, Int 6]. Other creative apps that children engaged in during play time in a self-motivated way included PuppetPals [48], an app to create, narrate and record a puppet show by screen-capturing



puppet movements, or Garage Band [17] which allowed them to create their own musical compositions.

### Home Exercises

Children were able to take the iPad home from February (see Fig.2), and this appeared to positively influence children's attitude to homework. The teacher felt that this also had a positive impact on their homework: *"You know, there is a wee boy in the class and he struggles, struggles, struggles with homework, and you wouldn't think he would, and his mum was complaining about it at parents' night. Saying 'I am fed up of saying to him come on and do your homework, do your homework'. He came in today. Now, he only got his homework yesterday, and he came in today, and he must have spent hours doing it, he made a really cool Pic Collage using all his spelling words."* [Teacher, Int T]. In general, children recognised the iPad was primarily a work tool even at home: *"I like doing my homework first, but when that's done then I listen to music."* [Bethany, Int 6]. However, other children found the iPad could offer distraction: *"At home I waste a lot of time on it. Like on games...like 'Candy Crush', like 'Geometry Dash', '4 in a row'. Those kind of things occupy a lot of time. Like I will look at the time and will be like 'I will just use it for 10 minutes' and like, no its 30 minutes already gone and I dont get any homework done!"* [Ann, Int 7].

All of these examples demonstrate how children interacted with the iPad to complete different learning activities. They show that children were engaged and motivated by iPad activities and illustrate how their creative engagement with the iPad went beyond structured learning activities. Children were able and competent enough to creatively come up with and execute their own ideas using the various iPad features, functions and apps at hand. We highlight that many of these activities involved various gatherings of children with an inherent need for mobility, as supported by the iPad.

### ROLE OF THE IPAD IN THE CLASSROOM

Analysing the different types of activities described above, we identified distinct roles that iPads can take on as part of classroom activities when not Forgotten or in Focus, namely: Friend, Functionary and Facilitator. These roles are described below, illustrated with examples from our observations.

#### Friend: The iPad as a Companion

From the beginning of the study we observed that children treated their iPad as more than just a functional device that would help them accomplish a task, but, rather, as a *Friend*. This was visible in the way they personalised their iPad, and how they kept their iPads in close proximity throughout the day, checking upon the device regularly.

##### Personalisation

Following their introduction to the classroom, children began to actively personalise their iPads, using both physical and digital tools. All iPads came with the same blue cover and stand provided by the school, and children were not allowed to change these. Working around these constraints, children created doodles on their iPad's name tag (see Fig. 10).

Children had more freedom in personalising their iPad's wallpaper, and they regularly modified it throughout the school



Figure 10. Children personalised their name labels [Obs].



Figure 11. Children constructed complex images for wallpaper [Vid].

year in creative ways. For example, wallpapers were created from photos of friends or images of interests from the web, and modified using iPad apps. In fact, we found that the wallpapers, to a certain extent, reflected children's increasing skills with the iPad and particular apps. There was also a social element to this personalisation, as children frequently shared their wallpapers with friends, which sometimes resulted in the imitation of certain styles or ideas. For example, when one child shared their wallpaper made from assembled and layered screen shots of their iPad's desktop, several children imitated this idea (see Fig. 11, [Vid]).

##### Keeping it Around

Children's behaviour towards the iPad during class activities when it was not in use, also demonstrates their personal relationship with the device. For example, they kept the iPad on their desks, even when not using it, in close reach, occasionally re-positioning it for no apparent reason, or touching the display to prevent it from entering sleep. We further observed examples of children taking advantage of the device's mobility as they carried the iPad around with them, even if not needed, as they moved about in the class or changed desks. These behaviours reflect on children's feelings of ownership toward their iPad, which they clearly considered as a precious personal artefact, maybe even as a companion, rather than just a helpful functional device.

Behaviours like these seemed to help children become accustomed to the iPads and establish an almost personal bond to the device. Physical personalisation and keeping the iPad around were behaviours we observed mostly at the beginning of the study when the iPads were around for just a few weeks. By the end of the study children were visibly less concerned about having the device nearby, and fiddling with it for no apparent reason became rarer. However, digital personalisation remained a common activity throughout the study. Children had changed or were actively changing their iPad's wallpapers during every study visit; from our first study day, none of the children used the default wallpaper.



### **iPad as a Functionary**

In 41% of non-Focus, non-Forgotten activity, we found that the iPad was used as, what we term, a *Functionary*. In these cases, the iPad was used to facilitate an exercise without being necessary to solve the task at hand. We observed examples of this across the curriculum, including languages, physical education (P.E.), arts, maths, and religious education; during individual as well as collaborative activities. We illustrate this Functionary role of the iPad in the examples below.

#### *Passive Display of Information*

In the role of a Functionary, the iPad was frequently used as a passive display to present exercise material, for instance, worksheets with questions to complete, images to copy onto paper (see Fig. 7), text passages to read, or other support material (e.g., a maths grid). In these cases the material presented on the iPad was integral to the task, but the use of the iPad itself was not—the learning material could have been presented, for example, on paper; the iPad was merely a different medium to display this material.

We also found that children made use of the iPad's form factor and physical characteristics to facilitate their classroom activities. For example, the iPad and stand were used to prop up a book or worksheet (see Fig. 4, top left).

#### *Replacement of Traditional Classroom Aids*

Other instances of the iPad facilitating classroom activities as a Functionary included the use of its interactive capabilities. For example, children used the iPad to take photographs of the classroom board, so they could more easily read or copy read its content from their desk. Occasionally, the teacher engaged children in playful competitive 'rapid fire' exercises where children had to answer maths questions as quickly as possible. Children used the 'Show Me' app [53] rather than a small whiteboard or notepad to write down their answers (see Fig. 4, top right). Children also often opted to use the calculator app or Google search, rather than a common calculator during maths exercises (see Fig. 4, bottom).

#### *A Functionary in Group Exercises*

From our observations we can see that Functionary activities were mainly used for individual or whole class activities, but less often during small or large-group exercises (individual and whole class activities account for 46% and 31.4% of all Functionary activities respectively).

We observed the iPad successfully working within a large group during 4.4% of all Functionary activities. An example of this was when children worked in ability-related groups completing a worksheet. Here, the iPad screen became a medium for sharing and discussion, e.g., when solving maths problems. Small-group activities account for 9.5% of activities classified as Functionary. For example, children collaboratively worked on a written exercise while the iPad showed Bloom's taxonomy (a well known taxonomy of learning objectives) to motivate their learning. Similar to large-group activities, the iPad enabled access to the material during group discussions but was not essential to the written task itself.

When working in pairs children used the iPad in 8.8% of all activities classified as Functionary, for example, to time each other during P.E. when completing fitness exercises.

### **The iPad as a Facilitator**

In 49% of all iPad-related classroom activities, when it was not Forgotten or in Focus, we found that the iPad was used as a *Facilitator*. Here, its technological capabilities were a requirement for the learning activity itself, where the activity could not be completed without it, as illustrated below.

#### *iPad Apps as Interactive Learning Tools*

Children mainly used the iPad in its Facilitator role when demonstrating learning outcomes of particular tasks. For example, children would prepare and give presentations using the PowerPoint [33] or Keynote [26] apps to demonstrate their understanding of certain topics. Similarly, children would consolidate their learning by writing stories or completing worksheets using apps such as Pages [41] or MS Word [34], or make posters or short comics using apps such as such as Book creator [3], PowerPoint or Pic Collage [44]. Children also learned how to record the accounts of a recent entrepreneurship activity on the iPad using MS Excel [32]. As described earlier, apps focusing on particular educational skills (e.g., Super Spellers [55], Crazy Cursive [10], Sumdog [54], King of Maths [27], Brain Training) offered children the opportunity to learn and practice core literacy and numeracy abilities, in a fun and accessible way.

We observed the iPad being used as a Facilitator throughout our study. However, children's ability and confidence with the iPad and the provided apps improved over time, which is reflected in both the efficiency of interaction with the iPad, the quality of the produced work, and children's ability to pick and choose apps that would best support their tasks. For example, during a social studies project, children worked in pairs to record a news video reporting on a tsunami [Obs, May]. This task involved the children making decisions about suitable apps, and using several apps to research, script and record the news story. The range of different apps and their use in combination, allowed children to explore their own individual approaches to similar tasks.

#### *Social Setup of Facilitator Activities*

Our observations show that 51.9% of Facilitator activities were individual activities—implying that paying more attention to the iPad made it harder to work with others. However, we also observed occasions where the iPad worked well in pairs (e.g., the gymnastics activity, see Fig. 9). When the iPad was involved in a Facilitator fashion during large and small group activities, children tended to divide up the task (as described previously), or they engaged in competitive activities. For example, the Sumdog app features a multi-player mode and performance tables for the class.

### **Fluid Boundaries between iPad Roles**

Our observations illustrated above show that each of the iPad roles, visible across a range of activities, manifest themselves in different ways. However, we found that within learning activities, the role of the iPad can fluidly shift and that the different roles sometimes build upon each other.

#### *Friend Role as a Basis for Functionary and Facilitator*

Building comfort and confidence around iPad use, which the Friend role facilitates, is key to activities where the iPad acts as a Functionary or Facilitator. Throughout our study, we

observed how children built their skills, knowledge and confidence around iPad use, to a point where they *appropriated* the iPad's physical and digital features. For example, as mentioned earlier, they used the iPad as a physical prop or freely combined different apps to accomplish a more complex task, without thinking about the intended use of the device or apps, but about how to best accomplish the task at hand.

Experiencing the iPad as a Friend appears to have a positive effect on children's approach and mastering of learning activities and on their overall learning experience. Our observations suggest that it was the personal relationship that children built with their iPad which encouraged them to freely and creatively explore the device's and their own capabilities. In a way, the Friend role of the iPad can be considered a foundation to the roles of Functionary and Facilitator.

#### *Friend or Foe?*

Besides the positive aspects of the Friend role, it is the same aspects that can also cause the iPad to become a distraction. For example, the constant checking on the iPad, even when it was not in use, was potentially initiated by children feeling precious about the device, in particular, when it was newly introduced. Personalisation activities such as creating new wallpapers took place during classroom activities—again, a potential distraction from learning activities. Our observations suggest that the ease of access to the range of functionalities and apps provided on the iPad, literally at children's fingertips, may invite for procrastination or even become a source of distraction (apps are easily opened and closed).

Sometimes, children became very engaged in seemingly productive, yet unnecessary activities, which prevented them from thinking about the actual learning activity in focus. For example, they would spend a lot of time choosing a font or font colour in their text editor before writing their essay. The sheer range of digital functionalities available on an iPad can potentially have a negative effect on children's attention span and their ability to focus. By the end of the school year, the children themselves recognised the negative side of the iPad. For example, when asked about the iPad's negative aspects Erin admitted that she would sometimes waste time on it, even at school, “[*playing*] silly games, searching silly stuff.” [Erin, Stat. June]. Similarly, Ann commented on her use of the iPad at home “*At home I waste a lot of time on it. Like on games.*” [Ann, Int 7]. It is therefore important to consider the iPad as both a Friend and a Foe: children's comfort and fun with it can also easily lead to unproductive and non-educational behaviour.

#### *Transitioning between Functionary & Facilitator Roles*

Our observations indicate that there are fluid boundaries between the Functionary and Facilitator roles of the iPad where one often shifts into the other. For example, in order to copy images from their iPads during creative activities (iPad in a Functionary role, see Fig. 7), children had to first search for an image using the web browser—an activity in which the iPad is used as a Facilitator. Similarly, when reading a book on the iPad (iPad as Functionary), sometimes children shifted back and forth between using the iPad in a Functionary and Facilitator way, by using the dictionary function within the

iBooks or adding new words to their personal vocabulary books in Book Creator (iPad as Facilitator).

These examples demonstrate the roles an iPad can play as part of classroom and learning activities: Friend, Functionary and Facilitator are somewhat flexible in terms of their impact on how activities are conducted or relate to each other.

## DISCUSSION

The findings of our study provide rich insights into how tablet devices such as iPads are used as part of classroom activities. By considering by the role of iPads in the classroom from child- and activity-centred perspective, emphasising how these fluidly transition and build upon each other, we expand on previous work in the area of educational tablet use. Furthermore, our activity-based framework of iPad roles (Forgotten, Friend/Foe, Functionary, Facilitator and Focus) adds to previous models [5, 29, 47] by providing a productive granularity for distinguishing between iPad-related activities as well as a new vocabulary to facilitate the design and study of tablet devices in classroom scenarios.

#### *Impact on Learning Activities*

Our observations suggest that within a social constructivist learning context [42], iPads can have a positive impact on learning activities, visible in children's increased motivation, engagement and sharing in their learning. Furthermore, children became more independent and gained self confidence when given the opportunity to work creatively and at their own pace. Both children and the teacher reported a greater enthusiasm for written work as the tablet enabled them to more easily produce things using a variety of methods to conduct their learning activities and (visually) frame their learning outcomes. The teacher felt it had a positive impact in other areas, too: “*Its increased motivation to do work. Better maths. Better story writing. Confidence... and the way they talk about things and the way that they display things is great.*” [Int T]. Over time, we witnessed how children's abilities with the iPad grew, generally gaining more autonomy over how to complete activities. At the beginning of the study, activities were often led by the teacher: “*Open the Book Creator app on your iPad*”. By the end of the study children more frequently made their own choices of apps.

The class teacher felt the introduction of the iPad was beneficial for all: “*Because the less able ones are finding it a good support tool for them. I think they are going home and playing the apps and taking their time going through it, and I think it is good for them. But I think that the more able ones are then seeing it as ‘What new way can I learn?’, ‘What new way can I show my understanding?’. And they are always teaching me and showing me things. So the more able kids are loving it. [...] I couldn't target a group of children and say they are getting the most benefit out of it because you can see them all.*” [Int T]. Children became ‘expert’ users sharing learned skills and shortcuts with the teacher and others in class. Children also started sharing their learning outside of school, with family and friends.

The mobility of the iPad supported children as they shared and worked with others. However, engaging in collaborative tasks was limited by complex or elaborate processes to share

information across devices in a lightweight manner. Children would benefit from a less complicated file sharing processes to better promote collaborative work.

A benefit of using the iPad in class is the provision quick and easy access to educational activities through specialised apps. However, narrowing learning activities to the scope of apps can, potentially, prohibit cross-curricular, holistic learning opportunities. Furthermore, determining the suitability of apps is currently in the hands of the teacher, who may not be able to apply close scrutiny to all of the apps functionalities and learning outcomes. In future, employing design strategies to allow for quick and easy evaluation of educational apps - perhaps identifying how apps meet curricular areas may help provide a better learning experience.

From a more general perspective, we cannot be sure that access to technology will not impact negatively on children's learning. For example, Amy explained that the iPad helped with spelling as "*(the iPad) sometimes give you the word before you finish writing that word. You just press the space bar and it puts that word in.*" [Int 2]. Similarly, Ben worried that the iPad may not improve his spelling as "*the iPad just auto corrects it.*" [Int 2]. Future studies need to investigate further how to deal with these kinds of technological shortcuts.

Our study took a broad approach to investigating iPad use, which limits more detailed insights into its learning impact. Future research has to investigate in more detail how iPad use affects learning in particular subject areas such as math or spelling. Our study can facilitate these future studies by providing a classification of iPad roles to use as a lens when observing in-class behaviours more closely.

#### *iPads as Mainstream School Technology?*

Our observations provide rich insights into how iPads were used across a range of subject areas. We found that the iPad was used in less than half (43.4%) of all classroom activities. When the iPad was in use, it was in use in a *facilitatory* way (that is the technology was required to complete the learning outcome), only 49% of the time. Furthermore, children were often supported by other traditional materials such as books or worksheets, alongside the iPad. This raises questions around the contributory factors that influence iPad use in school and how these can be used to exploit the learning capabilities of the iPad to the fullest. Considerations such as subject area, group size or even teacher experience may all contribute to the role of the iPad within the class.

Furthermore, age is an important factor to consider when introducing iPads into classrooms. Our child participants controlled the iPad and its application features with ease (e.g., they quickly became proficient in switching between apps). While there is evidence to suggest that children are capable of navigating an iPad from an early age [23], we have yet to investigate at which age they are able employ Friend, Functionary and Facilitator behaviours to educationally benefit.

#### *Temporal Aspect*

We observed a large range of learning activities, in a variety of social constellations across the duration of our study. It was this temporal aspect of our work that allowed us to develop our iPad roles. For example, the *Friend* role encompasses

how children's behaviours and attitudes changed over time: we observed how children's relationship with the iPad developed and interviews captured children's growing awareness of disruptive iPad use. Furthermore, we observed how children became more skilled with the iPad, completing learning activities confidently and in a way to suit them.

#### *Tablet Roles from a Design Perspective*

The iPad roles derived from our study open up possibilities to guide the design of future tablet devices and applications. Similar to [5, 12], our study supports a personal approach to the deployment of iPads in schools, as children achieve better continuity in their classwork, and benefit from increased engagement and autonomy in learning activities. Designers have yet to fully consider the inclusion of features to enhance physical and digital personalisation of an iPad. Considering the *Friend* role that an iPad can take on may provide guidance in this direction.

Similarly, design solutions to prohibit the negative aspects of the Friend behaviour, such as distractions from exercises, are important to prevent and counteract procrastination behaviours. In terms of the *Facilitator* role of the iPad, it is worthwhile considering how the current design can be improved, for example, including a pen for a better drawing and writing experience. As a *Functionary*, the iPad always offers up the opportunity to create better apps and games for an educational environment as well as for improved processes to deliver these in a working classroom.

Our study did not analyse the effect of particular interface and interaction design choices manifested in certain apps and how this influences classroom and learning activities. We acknowledge that app design can strongly influence children's experience in terms of learning and engagement and as such, the role of app design need to be considered not separately to the tablet technology itself but still as a unique factor. Future studies focusing on particular subject areas or app categories are required to analyse this aspect in detail.

## CONCLUSION

We observed and documented the integration and use of iPads into a UK Primary school over the course of eight months. Our study presents a rich description of in-class activities around iPad use, covering a range of subjects and group constellations. Based on our observations we quantify the role of the iPad within the classroom, and expand on current tablet based learning models. As classrooms move towards more technology in the classroom further research is needed to assess how these changes impact educationally on the children as well as consider how best to meet the current and future needs of this kind of environment. Our new child-centred classification of iPad use (Friend, Functionary or Facilitator), can enable new perspectives and discussion around the design and integration of tablets into school environments.

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## REFERENCES

1. Heejung An and Sandra Alon. 2013. iPad Implementation Models in K-12 School Environments: An Exploratory Case Study. In *Proceedings of Society for Information Technology & Teacher Education International Conference 2013*, Ron McBride and Michael Searson (Eds.). Association for the Advancement of Computing in Education (AACE), New Orleans, Louisiana, United States, 3005–3011. <http://www.editlib.org/p/48552>
2. Gary Beauchamp and Emily Hillier. 2014. *An Evaluation of iPad Implementation Across A Network of Primary Schools in Cardiff*. Cardiff: Cardiff Metropolitan University. <http://www.cardiffmet.ac.uk/education/research/Documents/iPadImplementation2014.pdf>
3. Book Creator for iPad 2015. Red Jumper Ltd. (2015). <https://itunes.apple.com/gb/app/book-creator-for-ipad-create/id442378070?mt=8>
4. Patricia Senn Breivik. 2005. 21st century learning and information literacy. *Change: The Magazine of Higher Learning* 37, 2 (2005), 21–27. DOI: <http://dx.doi.org/10.3200/CHNG.37.2.21-27>
5. Kevin Burden, Paul Hopkins, Trevor Male, Stewart Martin, and Christine Trala. 2012. iPad Scotland Evaluation. (2012). DOI: <http://dx.doi.org/10.13140/2.1.3593.5363> Retrieved on September 20, 2015 from <http://www.tablet-academy.com/uploads/news/Scotland-iPad-Evaluation.pdf>.
6. Kevin Burden and Trevor Male. 2013. *Edinburgh 1:1 Mobile Evaluation*. [https://digitalteachingandlearning.files.wordpress.com/2013/10/edinburgh\\_mobile\\_evaluation\\_2013.pdf](https://digitalteachingandlearning.files.wordpress.com/2013/10/edinburgh_mobile_evaluation_2013.pdf)
7. Cathy Cavanaugh, Jace Hargis, Stephen Munns, and Tayeb Kamali. 2013. iCelebrate teaching and learning: Sharing the iPad experience. *Journal of teaching and learning with technology* 1, 2 (2013), 1–12. <http://jotlt.indiana.edu/article/view/2163>
8. Daniel Chong. 2015. Division Wiz. The Rocket Studio. (2015). <https://itunes.apple.com/gb/app/division-wiz-free/id496191722?mt=8>
9. Sean Coughlin. 2014. Tablet computers in '70% of schools'. BBC News Article. (December 2014). Retrieved September 20, 2015 from <http://www.bbc.co.uk/news/education-30216408>.
10. Crazy Cursive 2015. MadeByEducators. (2015). <https://itunes.apple.com/gb/app/crazy-cursive-letters-joined/id788797222?mt=8>
11. John W Creswell. 2007. Qualitative enquiry and research design: Choosing among five approaches. (2007).
12. Susan Crichton, Nancy Stuewe, Karen Pegler, and Duncan White. 2011. Personal devices in public settings: Lessons learned from an iPod touch/iPad project. In *6th International Conference on e-Learning*. <http://www.ejel.org/volume10/issue1/p23>
13. Alma L Culén and Andrea Gasparini. 2011. iPad: a new classroom technology? A report from two pilot studies. *INFFuture Proceedings* (2011), 199–208.
14. Allison Druin, Elizabeth Foss, Leshell Hatley, Evan Golub, Mona Leigh Guha, Jerry Fails, and Hilary Hutchinson. 2009. How Children Search the Internet with Keyword Interfaces. In *Proceedings of the 8th International Conference on Interaction Design and Children (IDC '09)*. ACM, New York, NY, USA, 89–96. DOI: <http://dx.doi.org/10.1145/1551788.1551804>
15. Crystal Elliott, Kimberly Livengood, and Mary McGlamery. 2012. Teaching with technology: iPad use in the classroom. In *Proceedings of Society for Information Technology & Teacher Education International Conference 2012*, Paul Resta (Ed.). Association for the Advancement of Computing in Education (AACE), Austin, Texas, USA, 4084–4086. <http://www.editlib.org/p/40249>
16. Andrew Enever. 2015. A+ Spelling Superstar. (2015). <https://itunes.apple.com/us/app/a+-spelling-superstar/id832420917?mt=8>
17. GarageBand 2015. Apple. (2015). <https://itunes.apple.com/gb/app/garageband/id408709785?mt=8>
18. E Garcia and A Friedman. 2011. "There's an App for That": A Study Using Apple iPads in a United States History Classroom. *Studies in Teaching 2011 Research Digest* (2011), 31. DOI: <http://dx.doi.org/10.5923/j.edu.20120205.05>
19. Clifford Geertz. 2002. Thick description: Toward an interpretive theory of culture. *The interpretation of cultures* (2002), 537–56.
20. Steve Harrison, Deborah Tatar, and Phoebe Sengers. 2007. The three paradigms of HCI. In *Alt. Chi. Session at the SIGCHI Conference on Human Factors in Computing Systems San Jose, California, USA*. 1–18.
21. Sarah Henderson and Jeff Yeow. 2012. iPad in Education: A Case Study of iPad Adoption and Use in a Primary School. In *Proceedings of the 2012 45th Hawaii International Conference on System Sciences (HICSS '12)*. IEEE Computer Society, Washington, DC, USA, 78–87. DOI: <http://dx.doi.org/10.1109/HICSS.2012.390>
22. Steve Higgins, Gary Beauchamp, and Dave Miller. 2007. Reviewing the literature on interactive whiteboards. *Learning, Media and Technology* 32, 3 (2007), 213–225. DOI: <http://dx.doi.org/10.1080/17439880701511040>
23. Juan Pablo Hourcade, Sarah L. Mascher, David Wu, and Luiza Pantoja. 2015. Look, My Baby Is Using an iPad! An Analysis of YouTube Videos of Infants and Toddlers Using Tablets. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 1915–1924. DOI: <http://dx.doi.org/10.1145/2702123.2702266>

24. Winnie Hu. 2011. Math That Moves: Schools Embrace the iPad. The New York Times News Article. (January 2011). Retrieved January 5th, 2016 from <http://www.nytimes.com/2011/01/05/education/05tablets.html>.
25. Isa Jahnke, Lars Norqvist, and Andreas Olsson. 2013. Digital Didactical Designs in iPad-Classrooms. In *Scaling up Learning for Sustained Impact*, Davinia Hernández-Leo, Tobias Ley, Ralf Klammer, and Andreas Harrer (Eds.). Lecture Notes in Computer Science, Vol. 8095. Springer Berlin Heidelberg, 611–612. DOI : [http://dx.doi.org/10.1007/978-3-642-40814-4\\_76](http://dx.doi.org/10.1007/978-3-642-40814-4_76)
26. Keynote 2015. Apple. (2015). <https://itunes.apple.com/gb/app/keynote/id361285480?mt=8>
27. King of Maths 2015. Oddrobo Software AB. (2015). <https://itunes.apple.com/gb/app/king-of-maths/id473904402?mt=8>
28. Natalia Kucirkova, David Messer, Kieron Sheehy, and Carmen Fernández Panadero. 2014. Children's engagement with educational iPad apps: Insights from a Spanish classroom. *Computers & Education* 71 (2014), 175 – 184. DOI : <http://dx.doi.org/10.1016/j.compedu.2013.10.003>
29. Robert McCormick and Peter Scrimshaw. 2001. Information and Communications Technology, Knowledge and Pedagogy. *Education, Communication & Information* 1, 1 (2001), 37–57. DOI : <http://dx.doi.org/10.1080/14636310120048047>
30. Iain McPhee, Lisa Marks, and Dougie Marks. 2013. Examining the impact of the Apple 'iPad' on male and female classroom engagement in a primary school in Scotland. *Proceedings of ICICTE 2013* (2013), 443–451. <http://www.icicte.org/Proceedings2013/12-4-McPhee-Abstract2013.htm>
31. Bente Meyer. 2015. iPads in Inclusive Classrooms: Ecologies of Learning. In *E-Learning Systems, Environments and Approaches*, Pedro Isaacs, J. Michael Spector, Dirk Ifenthaler, and Demetrios G. Sampson (Eds.). Springer International Publishing, 25–37. DOI : [http://dx.doi.org/10.1007/978-3-319-05825-2\\_3](http://dx.doi.org/10.1007/978-3-319-05825-2_3)
32. Microsoft Excel 2015. Microsoft Corporation. (2015). <https://itunes.apple.com/gb/app/microsoft-excel/id586683407?mt=8>
33. Microsoft PowerPoint 2015. Microsoft Corporation. (2015). <https://itunes.apple.com/gb/app/microsoft-powerpoint/id586449534?mt=8>
34. Microsoft Word 2015. Microsoft Corporation. (2015). <https://itunes.apple.com/gb/app/microsoft-word/id586447913?mt=8>
35. Tom Moher, Syeda Hussain, Tim Halter, and Debi Kilb. 2005. Roomquake: Embedding Dynamic Phenomena Within the Physical Space of an Elementary School Classroom. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems (CHI EA '05)*. ACM, New York, NY, USA, 1665–1668. DOI : <http://dx.doi.org/10.1145/1056808.1056992>
36. M.R. Morris, A.J.B. Brush, and B.R. Meyers. 2007. Reading Revisited: Evaluating the Usability of Digital Display Surfaces for Active Reading Tasks. In *Horizontal Interactive Human-Computer Systems, 2007. TABLETOP '07. Second Annual IEEE International Workshop on*. 79–86. DOI : <http://dx.doi.org/10.1109/TABLETOP.2007.12>
37. Meghan Murphy. 2014. Why Some Schools Are Selling All Their iPads. (2014). <http://www.theatlantic.com/education/archive/2014/08/whats-the-best-device-for-interactive-learning/375567/>
38. David Nagel. 2014. One-Third of U.S. Students Use School-Issued Mobile Devices. BBC News Article. (August 2014). Retrieved September 20, 2015 from <https://goo.gl/ovjDuk>.
39. Cathleen A Norris and Elliot Soloway. 2011. Learning and Schooling in the Age of Mobilism. *Educational Technology* 51, 6 (2011), 3. <http://eric.ed.gov/?id=EJ956471>
40. Nathaniel Ostashewski and Doug Reid. 2013. The ipad in the classroom: Three implementation cases highlighting pedagogical activities, integration issues, and teacher professional development strategies. *Pedagogical applications and social effects of mobile technology integration* (2013), 25–41. <http://dx.doi.org/10.4018/978-1-4666-2985-1.ch002>
41. Pages 2015. Apple. (2015). <https://itunes.apple.com/gb/app/pages/id361309726?mt=8>
42. A Sullivan Palincsar. 2005. 12 Social constructivist perspectives on teaching and learning. *An introduction to Vygotsky* (2005), 285.
43. Seymour Papert. 1980. *Mindstorms: Children, computers, and powerful ideas*. Basic Books, Inc. <http://dl.acm.org/citation.cfm?id=1095592>
44. PicCollage 2015. Cardinal Blue Software Inc.. (2015). <https://itunes.apple.com/gb/app/pic-collage-photo-editor-effects/id448639966?mt=8>
45. Marc Prensky. 2009. H. sapiens digital: From digital immigrants and digital natives to digital wisdom. *Innovate: journal of online education* 5, 3 (2009), 1. <http://www.wisdompage.com/Prensky01.html>
46. Luis P. Prieto, Martina Holenko Dlab, Israel Gutiérrez, Mahmoud Abdulwahed, and Walid Balid. 2011. Orchestrating Technology Enhanced Learning: A Literature Review and a Conceptual Framework. *Int. J. Technol. Enhanc. Learn.* 3, 6 (Feb. 2011), 583–598. DOI : <http://dx.doi.org/10.1504/IJTEL.2011.045449>

47. Ruben R Puentedura. 2015. SAMR: Guiding development. (2015).  
[http://www.hippasus.com/rrpweblog/archives/2012/01/19/SAMR\\_GuidingDevelopment.pdf](http://www.hippasus.com/rrpweblog/archives/2012/01/19/SAMR_GuidingDevelopment.pdf)
48. Puppet Pals HD 2015. Polished Play, LLC. (2015).  
<https://itunes.apple.com/gb/app/puppet-pals-hd/id342076546?mt=8>
49. Jeremy Roschelle, Deborah Tatar, S.R. Chaudhury, Y. Dimitriadis, C. Patton, and C. DiGiano. 2007. Ink, Improvisation, and Interactive Engagement: Learning with Tablets. *Computer* 40, 9 (Sept 2007), 42–48. DOI :  
<http://dx.doi.org/10.1109/MC.2007.321>
50. Education Scotland. 2015. Introduction - Active spelling strategies - Resources. (2015).  
<http://www.educationscotland.gov.uk/resources/practice/a/activespelling/intro.asp>
51. Karen Sheingold, Janet Kane, and Mari Endreweit. 1983. Microcomputer Use in Schools: Developing a Research Agenda. *Harvard Educational Review* 53, 4 (1983), 412–432. DOI :<http://dx.doi.org/10.17763/haer.53.4.q42t234826087673>
52. Christopher Sherman. 2012. Texas School District Embarks On Widespread iPad Program To Close Digital Divide. Huffington Post News Article. (Febuary 2012). Retrieved January 5th, 2016 from  
[http://www.huffingtonpost.com/2012/02/27/texas-school-district-emb\\_n\\_1305711.html](http://www.huffingtonpost.com/2012/02/27/texas-school-district-emb_n_1305711.html).
53. Showme Interactive Whiteboard 2015. Learnbat Inc.. (2015). <https://itunes.apple.com/gb/app/showme-interactive-whiteboard/id445066279?mt=8>
54. Sumdog 2015. Sumdog. Sumdog Ltd. (2015). <https://itunes.apple.com/gb/app/sumdog/id783577770?mt=8>
55. Super Speller 2015. Quiet Spark: Create Your Own Spelling Tests. (2015). <https://itunes.apple.com/gb/app/super-speller-create-your/id483480630?mt=8>
56. Bernie Trilling and Charles Fadel. 2009. *21st century skills: Learning for life in our times*. John Wiley & Sons. <http://21stcenturyskillsbook.com/>
57. Robert K Yin. 2009. *Case Study Research: Design and Methods* (4th ed.).
58. Susan A. Zammit. 1992. Factors facilitating or hindering the use of computers in schools. *Educational Research* 34, 1 (1992), 57–66. DOI :  
<http://dx.doi.org/10.1080/0013188920340106>