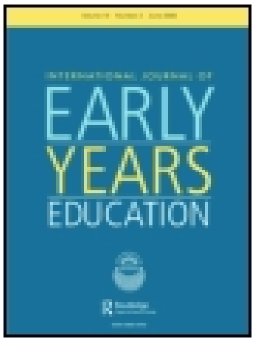

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International Journal of Early Years Education

ISSN: 0966-9760 (Print) 1469-8463 (Online) Journal homepage: http://www.tandfonline.com/loi/ciey20

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INTERNATIONAL JOURNAL OF EARLY YEARS EDUCATION, 2018
https://doi.org/10.1080/09669760.2018.1439368

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Tablets as an educational tool for enhancing preschool science

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ABSTRACT

Information communication technologies (ICT) is increasingly being introduced in the preschool level, but questions have been raised regarding its potential to develop content knowledge or specific skills. This quasi-experimental study looked into the impact that hand-held tablets can have on science learning outcomes in five-year-olds. Four classes from two preschool institutions in Buenos Aires, Argentina, were selected for a six-week intervention. All four classes received training and an inquiry-based science teaching sequence, with one group from each institution also receiving tablets and specific guidance on how to incorporate them into their science lessons. Post-intervention test results showed significant improvements in science outcomes for all students, but no significant difference between the tablet-enhanced classrooms and those taught without ICT. Challenges and opportunities are discussed with regard to including tablets for teaching science at the preschool level.

ARTICLE HISTORY
Received 20 December 2016
Accepted 10 January 2018

KEYWORDS
Tablets; science; inquiry; ICT; preschool

Introduction

Over the last few decades technology has become an increasingly present tool in education and in science education in particular. Although information communication technologies (ICT) have spread into nearly all educational levels, research has given limited conclusive results about the actual impact that technology has on educational outcomes, either in science or otherwise (Fu 2013). Results comparing digitalised classrooms (i.e. those including the use of technologies such as computers, tablets or smartphones) with traditional teaching methods have been varied, with most studies showing significant improvements, but some showing no difference and others yet a decrease in academic results and student thinking skills (Kozma 2005).

There are also large differences in how teachers use, and perceive the value of, ICT in their classrooms (McKnight et al. 2016). Large-scale reviews such as the one conducted by Tamim et al. (2011) on various types of technologies have found modest benefits in ICT-enhanced classrooms, with the highest gains found at K-12 levels when teachers use ICT as an additional teaching strategy, as opposed to using ICT for direct instruction (such as

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during online distance learning for university courses) (ARCC 2013; Gulek and Demirtas 2005; Ringstaff and Kelley 2002).

Although ICT has expanded rapidly at all educational levels, it has not done so to the same degree in preschool. Despite this, preschool age children are increasingly accustomed to using ICT at home, with many parents – though not all – feeling that ICT should be included in preschool education as part of 'preparing for the future' (Plowman et al. 2012). Along the same lines, there is still a divide between teachers who embrace and those who reject ICT becoming embedded into preschool (Laffey 2004; Lindahl and Folkesson 2012).

As in other educational levels, research on the use of ICT in preschool has shown mixed results. On the one hand, some studies have found that technologies such as computers can improve literacy, including for those students with special educational needs (Mioduser, Tur-Kaspa, and Leitner 2000). There is also evidence that, if paired with appropriate teaching approaches, including ICT in teaching can have significant impact on learning outcomes in areas such as literacy or mathematics (Vernadakis et al. 2005).

Although some studies suggest that ICT could be used effectively for independent play-based learning, this is not always easy to achieve, particularly if children are left to play freely as complete novices (Plowman and Stephen 2005). Another of the concerns regarding the use of ICT in preschool is that it may foment 'passive' learning and distract from more pressing needs (Cordes and Miller 2000), and some research has shown that, unless tasks are carefully selected, increasing computer time can lead to antisocial behaviour in young children (Gulay 2011).

This study aims to look at how hand-held touch screen tablets impact preschool children's learning in science, a topic that has been little explored. Tablets are small, relatively cheap and versatile tools, which have already been tried and tested in different educational levels (Ditzler, Hong, and Strudler 2016; Sheehy et al. 2005). They are argued to be particularly relevant for preschool, as they can be used intuitively without the need for fully developed literacy skills – young children are able to use touch screen tablets by recognising icons without needing to read instructions (Couse and Chen 2010; Marés 2012). For science, in particular, tablets could provide the opportunity of creating a 'mobile laboratory' – various apps and functions can be used to measure, photograph, film and share findings.

Current research has been looking at the use of more recent technologies such as tablets (including iPads) at university, school and preschool levels. In higher education and 1–12 school levels results on academic outcomes are promising although not transformative, and depend on multiple factors – much in line with universal findings regarding ICT in education generally (Banister 2010; Butcher 2016). In preschool, tablet-specific research is limited and tends to focus on the notions and perceptions of teachers regarding their introduction to this academic level, but there are a few examples of experimental and quasi-experimental approaches to impact evaluation. As one example, Schacter et al. (2016) found that using tablet-based play improved mathematics outcomes in kindergarten using discipline-specific apps in a randomised control experiment. Couse and Chen (2010) looked at tablet use 3- to 5-year-olds and found that student engagement improved (particularly in older pupils) as well as increases in pupils ability to overcome frustration. In particular, the mobile element of tablets seems to promote 'gathering round' and sharing, and therefore increases social interactions, collaboration and research skills amongst students and teachers (Moore and Keys Adair 2015).

In Argentina, the context of this study, as well as in other countries, preschool has recently found itself centre stage of the national education debates. New proposals to increase preschool places and improve learning conditions for 3–5 years old have been announced, and conversations around the developmental importance of the stage are increasingly common (Argentine Ministry of Sports and Education 2015). Preschool is of key importance, particularly for children who come from socially disadvantaged backgrounds (Melhuish 2004). Argentina has also had national and state ICT programmes, which aimed to give all public school students access to technology, and other programmes are currently under development to extend ICT to the preschool level.

At the same time, there is an ongoing discussion regarding the best ways to introduce inquiry-based approaches to science at the preschool level (Furman 2016; Samarapungavan, Patrick, and Mantzicopoulos 2011). This approach encourages children to develop scientific skills such as measuring, collaborating with others, discussing, collecting and analysing data and making predictions (Byrne, Rietdijk, and Cheek 2016; Cremin et al. 2015). Research into cognitive development shows that children can begin to acquire scientific thought processes from a very young age, making preschool a rich environment for the introduction to the wonders of science, which can then be built upon at later educational levels (Gopnik 2012; Klahr, Zimmerman, and Jirout 2011). Along these lines, some have argued that incorporating ICT may have the potential to enhance the development of inquiry-based skills in children, although little has been explored at the preschool level (Kubieck 2005; Osborne and Hennessy 2003).

In this context, the main aim of this research paper was to better understand:

- What is the impact of using tablets as part of an inquiry-based science teaching sequence on preschool children's science learning outcomes?
- What opportunities and challenges are involved in introducing tablets as a tool for teaching preschool science?

To answer these questions, we conducted a quasi-experimental study. Two schools were selected, each with two class divisions comprised approximately 20 five-year-olds. In each school, both classes carried out the same six-week inquiry-based teaching sequence, with one class integrating tablet-based activities to their lessons. Teachers were trained to deliver the sequence, with the only difference between groups being the inclusion of tablets. Pre- and post-tests of 12 students from each group were conducted, as well as in-depth teacher and principal interviews.

Methodology

Participating institutions and students: context and selection

Interventions were carried out in two co-ed preschool public institutions in the municipality of Vicente Lopez, Argentina. Both institutions selected are typically representative of middle and lower-middle class education establishments in the municipality. In total, 47 students (24 females and 23 males) aged between 5 and 6 were involved, as well as 4 teachers and both principals.

Over the last few years, through a variety of programmes implemented at regional and national levels, there has been an increase in the ICT tools made available for educational institutions. Vicente Lopez, in particular, has embraced the interventions, providing schools with services such as ICT specialists and computer labs. In this respect, it is fairly anomalous, but a good place in which to evaluate the impact of ICT education tools, as they already form a part of the current educational landscape.

We worked with four teachers, all of whom had taught at the preschool level for an average of 15 years. Due to the particularity of Vicente Lopez, all participating teachers had experience of using ICT to at least some degree, since they had received prior training on the use of computers in the classroom. Two teachers who expressed to feel more comfortable with the use of technology volunteered to use the tablets for this study (and the other two teachers were assigned to the non-ICT control group) rather than being randomly allocated, making this study quasi-experimental in nature.

Professional development programme

All four teachers participated in a professional development programme throughout the duration of this study. Teachers and researchers met on two occasions for two-hour sessions prior to the implementation of the project, during which time teachers reviewed inquiry-science approaches and were given a sequence of lessons (hereafter 'teaching sequence') to implement in their classrooms. In the case of the ICT-enhanced classrooms, teachers received two extra 1-hour sessions in which researchers explained and went over the relevant features of the tablets. Three more 1-hour meetings were also held with all four teachers over the six-week intervention to support and monitor the implementation of the lessons.

The teaching sequence was based on the topic of fungi and food decomposition. The sequence followed a constructivist and inquiry-science framework, as endorsed by the national curriculum frameworks, where students and teachers co-construct and evaluate shared knowledge based on activities that foment observing, testing and creating models of the world (Samarapungavan, Patrick, and Mantzicopoulos 2011). Although both the ICT-enhanced and control group teaching sequence were developed by the researchers, all four teachers were involved and participative in the adaptation of the lesson plans to their own classrooms. Sequences were designed in parallel and essentially identical, and it is worth noting that the intervention group did not simply receive a 'digital' version of the sequence, but rather an intentional intervention designed to truly take advantage of the potential marginal benefits of technology above and beyond inquiry-based approaches (such as allowing students to record their work through photographs, research answers using the internet or preparing digital presentations with which to show and share their work). We also note that the control group used no technology at all in their lessons (such as photos or videos) to be able to truly compare the value-added of integrating all aspects of tablets into early years science teaching.

The teaching sequences comprised two 40-minute weekly activities (a total of 12 activities) based around observing foodstuffs at different stages of decomposition, comparing these with other materials and under different conditions of temperature and humidity, observing and measuring changes, as well as recording and collecting data, registering their findings and presenting their opinions with peers. This allowed children to take part in guided investigations, and were meant to provide authentic opportunities for them to 'do science' within their school context.

The ICT-enhanced version provided preschoolers with the opportunity to digitally collect and record results, watch videos and offer new ways of sharing learning between peers (see Table 1 for a comparison between the control and intervention teaching sequence). The control group was supplied with books and other non-digitised sources of information. The intervention group students also received two extra lessons on 'how to use a tablet' from their teachers (e.g. saving documents, usage of specific apps, etc.) before starting the science unit, in order to familiarise the children with the tool.

Data collection and analysis

To answer our first research question, regarding the impact of ICT on science learning, a selection of students completed a semi-structured oral test. The same test was used as both the pre- and post-test, so as to accurately capture changes in student perceptions and understandings. A sample of 6 students was tested from each class (a total of 24 students). Teachers helped identify children so that the researchers could test two 'high achievers', 'middle achievers' and 'low achievers', balancing for age and gender, from each group (see Table 2). Choosing this balanced selection of students allowed us to see the gains made from different starting points and interest levels, as well as an insight to potential gender differences.

The test involved five open-ended questions regarding the process of food decomposition, contextualised as everyday problems (see Figure 1 for an example). Tests were conducted and recorded by researchers, before being transcribed verbatim.

The verbatim oral test transcriptions were then analysed and results were scored according to the criteria shown in Table 3. The categories and the rubric used were designed by researchers, established based on the different levels of achievement expected for students of that age group (Argentine Ministry of Sports and Education 2004;

Table 1. Comparison of teaching activities in the control and intervention group (with use of tablet).

Activity in teaching sequence (based on specific science skills)	Control group	Tablet group
Observing	Use of hand-held magnifying glass	Use of digital magnifying glass Digital photographs Digital drawings Digital writing Group digital 'science agenda'
Recording	Traditional drawing and writing activities Whole class science workbook	
Measuring	Traditional measuring instruments used over physical objects	Non-conventional instruments used over digital photographs Digital measuring instruments
Comparing	Science workbook Printed tables on which to draw and write collectively	Collaborative digital science workbook (with photographs, digital drawings and annotations)
Communicating	Oral presentations using posters and a flyer designed by students	Oral presentations using digital slides, which included the digital workbook as well as a video made by students
Researching (finding additional information from external sources)	Provided with the preschool's science textbooks	Using videos and websites (such as Wikipedia) for additional information

Table 2. Number of students interviewed for pre- and post-test in each school and intervention group.

	School A		School B	
Number of students	Control	Tablets	Control	Tablets
Number of pre-test students interviewed	11	12	12	12
Number of post-test students interviewed	10	10	10	8

Note: The reduction in the number of post-test students interviewed was due to students being absent on the final day of the study.

Student interview questions (*Italics show what was being evaluated with each question*)

Question 1.

I live in a house which has a garden full of fruit trees. The other day I went to the bottom of my my garden and saw that underneath a tree an orange had fallen on the floor! I left it there and took this photograph:

I went back a few days later and saw this, so I took the second photograph:

Can you notice any differences between the photographs? (*observation, description, comparison*)

a. What do you think happened? (*causal change relationships*)
b. Where did the "stain" (use the word they use) come from? (*ideas about fungi reproduction*)

I left it a few more days and then went back to the tree.

c. How do you imagine that the orange had changed in those days? Can you draw how the orange would look? (*predictions and ideas about the process of decomposition*).

Figure 1. Pre- and post-test interview question.

Table 3. Criteria and examples of student responses to the oral test.

Score	Description	Example
Omitted	Student does not answer or replies 'I don't know'	'I can't remember'
Naive	Answer has no grounding in science facts, being based instead on 'common sense' or misconceptions	'The bugs ate the bread and left it like that'
In process	Answer has some elements of grounding in scientific knowledge	'The bread went mouldy as it was wet and warm'
Advanced	A fully correct, scientifically sound answer	'The bread went bad as the bacteria got it and it decomposed. It needs to be cold, in the fridge, so they can't do that.'

Samarapungavan, Patrick, and Mantzicopoulos 2011). Questions were equally weighted throughout the test, as they were designed with similar levels of difficulty and importance.

Responses to the questions were graded by two researchers from the investigation team, working together from the transcripts to achieve consensus. From this, pre- and post-test scores were compared. Test results were subjected to a chi-squared categorical variables test, looking for differences in learning outcomes between pre- and post-test results. The chi-squared was chosen test was used to understand if there was a significant difference in the distribution of the answers; i.e. if there were there similar proportions of omitted, naive, in process and advanced answers in each group and across schools.

To answer our second research question regarding challenges and opportunities, in-depth semi-structured interviews were carried out with all participating teachers, principals and ICT specialists based in the school. Interviews were carried out by researchers, recorded and transcribed. Data were analysed using a grounded approach, looking for evidence of the difficulties and satisfactions that practitioners reported whilst implementing the teaching sequence. Key themes that emerged throughout involved perceived changes in student outcomes and attitudes, as well as the difficulties, opportunities and achievements teachers reported and principles perceived throughout the programme. As with the student test results, teachers and principal interviews were jointly coded by two researchers from the investigation team.

Results

Impact on student learning

Our first research question was regarding the impact of tablets on students' science learning. To measure this, pre-test and post-test scores of student oral assessments were compared and analysed.

Test results showed no initial differences between schools (School 1 scoring 3% correct, 32% in process, 51% naïve and 14% omitted, with School 2 scoring 2%, 28%, 44% and 26%, respectively, p-value = 0.323, chi^2 test = 3.4827), which allowed us to group student results by modality of intervention (tablet versus control groups). Also, no significant differences between control and tablet groups were found in the pre-test scores in any of the categories of answers (omitted, naïve, in process or advanced – see lighter–coloured bars in Figure 2) (Control Group scoring 1% correct, 31% in process, 45% naïve and 23% omitted, and ICT-enhanced classrooms scoring 4%, 30%, 51% and 15%, respectively, p-value = 0.447, chi^2 = 2.66). Both groups showed a low level of pre-test content knowledge (regarding fungi and their role in food decomposition) and scientific skills levels (such as observation, measuring and planning simple experiments), with fewer than 5% of students were able to give advanced answers. This gives confidence that all post-test differences, also shown in darker colours in Figure 2, were due to the teaching sequence implemented and not due to initial differences in cognitive ability of the children in each group.

Post-test results showed significant improvements in student scientific skills and knowledge (p-value = 0.000, chi^2 = 45.59). Both tablet and control groups saw a large increase in the number of advanced answers given after the six-week teaching sequence. More specifically, as well as an overall improvement across both groups, there was also a decrease in the number of students omitting or giving naïve (non-scientific) answers.

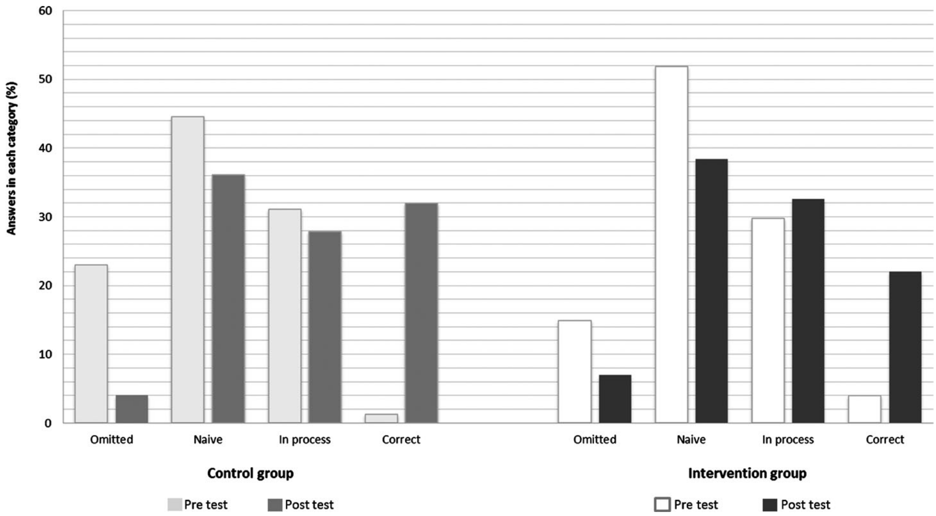

Figure 2. Pre- and post-test scores in the control and tablet group.

However, looking specifically at the effect of introducing tablet computers to the teaching sequence, there were no significant differences in post-test results between intervention and control groups (Control Group 1 scoring 32% correct, 28% in process, 36% naïve and 4% omitted, and ICT-enhanced Group scoring 22%, 33%, 38% and 7%, respectively, p-value = 0.439, chi^2 = 2.71). Both control and intervention groups showed similar improvements on the science content and capabilities assessed in the post-test, implying that tablets do not improve the specific science learning outcomes assessed in this study (in fact, data suggest a slight though non-significant negative trend for the tablet group). In this sense, we can see that all classes improved their science learning outcomes irrespective of having tablets introduced to their science lessons.

Opportunities regarding the integration of tablets into inquiry-based science teaching

Our second research question was regarding the opportunities and challenges associated with introducing tablets to preschool science. Looking at opportunities, we can see that teacher and principal perceptions all showed that they felt that students had improved their knowledge and abilities over the course of the sequence. In particular, teachers felt that the approach given by the sequence allowed students to appreciate 'everyday occurrences' with more scientific methods and that the activities suggested allowed them to develop interpersonal skills such as listening, collaborating and communicating, as the following interview fragments reveal:

> The students learned to observe with more detail, to spend more time, because they needed to sit in front of the trays for a fairly long time. (Teacher, tablet group)

> For me the value was in each student having a hypothesis, and for the others to listen to that hypothesis, and learn from each other there. (Teacher, control group)

In particular, several teachers and principals noted on the value of teaching children to wait and observe intentionally as an unexpected outcome of teaching using the sequences (in both the control and ICT group). As one of the principals noted:

> One of the things I felt that they learnt was to stop and look at everyday things, to actually observe them, investigate, be interested in the quotidian things that surround them because we're talking about food.[..] They learnt to use equipment like the magnifying glasses, which, even though they've seen them in science club, they never used them regularly or on a tablet, right? I think that´s where the largest focus was on, observing our everyday surroundings and trying to understand them. (Principal)

Although science learning outcomes were not statistically different between groups, teachers and principals agreed that, in the intervention group, children started to develop digital literacy, showing a large increase in their competency with the tablets. Initially, children were able to use the tablets without guided instruction for simple tasks such as opening and closing apps, taking photos and changing the size of images. By the end of the sequence, teachers pointed out that even those children who initially presented difficulties with the technology appeared confident and more able. Autonomy and responsibility were also increased amongst the students, with teachers feeling that the tablets in particular were a good tool for fomenting these particular skills. Teachers in the tablets group also highlighted improvements in attitude, caring and engagement, as well as other, 'softer' skills that were developed as a result of working with the technology, highlighting the value of having children work with these devices on a small group basis, as this excerpt shows:

> We could have watched video on the computer, but it wouldn't have been the same, this time as it was their tablet and they worked in groups, the work belonged to the group and they knew they were responsible for it, making sure nothing got lost, that no one could touch their document or photos. So I think we also learned about responsibility, respecting others, their opinions. That was a big plus about working with the technology (Teacher, tablet group)

As well as this increase in autonomy and digital literacy, the two teachers from the tablet group especially valued the 'mobile laboratory' element of the tablet, noting that if experiments were conducted without tablets they usually required specific items or equipment (such as a magnifying glass or thermometer). In particular, they were satisfied with the results of taking photographs, which allowed children to easily record their findings. Tablets were used as a 'science booklet' where they could record and share their work and findings.

Challenges regarding the integration of tablets into inquiry-based science teaching

As well as opportunities, several difficulties were also encountered during implementation as evidenced from teacher and principal interviews. In the first place, we found some challenges in preparing teachers to teach using inquiry-based approaches for science in both groups. Although supported by the science education literature (Samarapungavan, Patrick, and Mantzicopoulos 2011), this approach is not commonly used nor taught during teacher training in Argentina, the context of this study, and as such it presented various difficulties for the teachers. Along these lines, researchers' support was essential in order to scaffold teachers' use of the sequence, especially when deepening their biology content knowledge regarding food decomposition by fungi.

Although all teachers were experienced with the integration of ICT into teaching, all of them expressed feeling unconfident with use of tablets as a tool for learning at the beginning of the intervention. As one of the teachers described, there were several prior steps needed when guiding students to feel confident and capable in using the tablets:

> It was hard at the beginning to manage the tablets, maybe they were tricky to use, there was a lot to learn to be able to use the tablets, first as a tool, then organizing ourselves to use them well, know where to plug in each part … (Teacher, tablet group)

However, this uneasiness diminished as the sequence progressed, as they started to see that children easily incorporated tablets as part of their everyday activities. One principal noted that although teachers were uneasy with the technology to begin with (and that students may have picked up on this), as time went on both teachers and students were able to feel more confident.

In terms of the impact of tablets on teaching, one of the concerns noted by teachers was that the novelty aspect of the medium (in this case, taking photographs with the tablet) sometimes overrode the pedagogical activity itself. She noted that students were more enthused by using the tablets that by actually observing and recording the phenomena they were studying. However, the concern about how to position the tablet as a learning tool, and not simply a toy, was quelled by the end of the intervention, with teachers noting the pedagogical value of the tablet, as this teacher reflects:

> The kids used to relate the tablets with playing or games. I think that was one of the biggest learning outcomes they had, that the tablet can be used in a different way. Afterwards they learnt that it had information and games and all the rest, but for this project we were going to use it in this way [for science]. (Teacher, tablet group)

Discussion and conclusion

This study looked at the impact of incorporating tablets on preschool children's science learning outcomes, as well as the challenges and opportunities involved. We found that the implementation of a six-week inquiry-based science programme improved learning outcomes for 5-year-old preschoolers, although there were no significant differences between the intervention (tablet-enhanced) and control group (no ICT). Students in both groups improved in both their science content and skill levels, irrespective of having tablets or not. However, as seen in other studies, the use of tablets in science favoured increased autonomy, collaboration, independence and improved motivation and interaction in the children (Marés 2012; Moore and Keys Adair 2015). There was an increase in digital literacy, and other benefits highlighted from the post-sequence interviews with teachers and principals such as fomenting responsibility in the children.

Firstly, in response to our first research question, we found overall increases in student outcomes as a result of the intervention as a whole, independently of whether tablets were used or not. The increases in learning outcomes were substantial, particularly given the short time frame of the intervention. A large percentage of students were able to move from 'naïve' to at least partially scientifically correct answers. Teachers and principals were also satisfied with results, showing that interventions of this type can and do have positive outcomes for all involved, despite challenges and difficulties encountered. Particularly, as we mentioned, teachers highlighted positive changes in their attitudes towards science teaching (an area which is sometimes left behind in Argentine preschools), and a new appreciation for inquiry-based approaches, and the active role that students play during science investigations and experiments.

Our findings are in keeping with what others have found before, namely that ICT or tablets do not improve outcomes in and of themselves, but that the form of instruction is far more important than the tools utilised (Fu 2013; Vernadakis et al. 2005). In this case, using a well-designed, collaboratively planned science teaching sequence had a greater impact on learning outcomes than the differential advantage of including tablets. The tablets did improve digital literacy, as expected, and there were no ongoing frustrations or irresolvable problems with utilising the technology. Students responded well to the tablets, quickly picking up the skills needed to incorporate them as learning tools, similar to what has been seen in other investigations with children of this age.

It is worth noting that this study presents several limitations. The largest limitation in this study is the small sample size, which was further exacerbated by several students missing the post-test due to absences (due to illness at the end of the study). Using a sample of this size decreases the chance of finding a significant difference between treatments. However, the trend from this results shows a decrease in student outcomes when ICT is added, mirroring other studies that suggest teachers may find incorporating both new teaching strategies and ICT at the same time challenging to the point of detriment in student results (Berlinski and Busso 2013).

Another limitation was the quasi-experimental methodology. As teachers chose to be the treatment group, rather than being randomly allocated, there may have been an implicit bias in the teachers' behaviour and teaching practice. However, as the results show a slight negative tendency in incorporating ICT, and the bias would have been positive (supposing that those teachers who volunteer to work with ICT may inherently be more comfortable with the technology), we feel this bias is likely insignificant. For more detailed and powerful statistical results, a larger sample size and experimental design would need to be utilised in a future study.

A question that arose for us was: Why *didn't* student outcomes, or even science inquiry skills, improve with the addition of technology? As large-scale research does generally suggest that technology can improve outcomes (Fu 2013), why was that not the case in this intervention when compared with the control group?

One possible reason why outcomes might not be positively affected is that technology can distract teachers from doing 'the basics' right, especially when working with a new teaching approach (as inquiry-based learning was for our teachers). This was found in a large-scale experimental study by Berlinski and Busso (2013) in Costa Rica, where the untouched control group did significantly better than all ICT-enhanced intervention groups. In this case, perhaps the ICT made up for losses in learning brought about by the distraction factor, or even individual class cultures, which could play a large effect in a sample size this small. This mirrors findings by Butcher (2016) in a further education setting.

Regarding other student outcomes, the ability to use and manipulate new technology with familiarity and ease is part of digital literacy, which is increasingly cited as a key part of educating for the future. It is also crucial for preschool in itself, allowing students to better understand and interact with the digital world which increasingly surrounds them. Our own research supports that found by others, which is that introducing ICT into preschool allows students to develop this crucial skills further.

One of the interesting aspects of introducing ICT in this manner is also its effect on the learning community of the classroom. When ICT is introduced into the classroom in a more nuanced way, and less as a result of external expert training, this allows teachers and students to co-learn new technical skills (Beauchamp, Burden, and Abbinett 2015), enhancing peer-learning, as well as positioning some students as 'experts' who have something special to teach to their classmates.

Finally, our study also inquired about the ease of implementation of tablets as a resource for learning in preschool settings. One of the questions raised was whether this same intervention would have had the same impact in another municipality, as this was one which already had a trajectory of working specifically with ICT. Despite their familiarity with ICT, there were considerable challenges throughout the implementation, meaning that perhaps these would have been even more pronounced had this same project been carried out in a less technologically prepared area. Our study points to the fact that teacher preparation (including in-service support) and a shift in the attitudes of those still resistant to the inclusion of ICT in preschool, is necessary for truly effective and meaningful integration of ICT into preschool learning. This study provides the ground for further research into the best way of preparing teachers for effective preschool science learning with ICT tools.

As we all know, technology clearly changes the role of the teacher (McKnight et al. 2016), but this needs to be rethought carefully for the digital age in which preschoolers are growing into.

Disclosure statement

No potential conflict of interest was reported by the authors.

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