Tablet use in primary education: Adoption hurdlesand attitude determinants

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Abstract In the Netherlands, six primary schools recently participated in a pilot program, creating an educational environment in which children use a tablet PC. In these six schools, two studies are conducted. The first study highlights the process by which primary schools adopted tablet PCs by means of interviews based on diffusion of innovation theory. All stages are discussed: Knowledge, persuasion, decision, implementation, and confirmation. Two tablet systems are considered: closed and open systems. In the second study, a questionnaire was administered among primary school children in the pilot schools. Factors that affected the general attitude towards tablet PCs are perceived usefulness, perceived ease of use, interest in the task and independence. Social influence and prior experience with tablets did not affect the overall attitude. The results of both studies provide several recommendations on how tablet PCs can contribute to educational improvements.

Keywords Primary education · Tablet · Handheld · Computer · Adoption · Acceptance

1 Introduction

Information and communication technologies (ICTs) increasingly contribute to efficient, effective and more compelling teaching (Brummel and Amerongen 2011). In most developed countries, schools have incorporated computer use in their curricula. Although this has not yet fully reached the heart of the debate in all educational programs, new technologies empower learners and contribute to learning itself (Buckingham 2007). With the popularity of tablet computers at home, schools face the decision of using the tablet PC rather than textbooks and exercise books for education. The common objective of schools for using the tablet PC in education is preparing children for work and life in the 21st century (Clarke, Svanaes, Zimmermann

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et al. 2013). In the Netherlands, six primary schools recently participated in a pilot program, creating an educational environment in which children use a tablet PC rather than textbooks and exercise books. The six schools were one of the earliest adopters of tablets as an educational tool in the classroom in the Netherlands. The schools participating in the pilot program use one of two different tablet systems: an open system (like iPad) or a closed system. The open system allows users to adjust the tablet PC to their personal preferences (as those available for regular purposes). The tablets have an Internet connection, and it is possible to install applications on them. The closed tablet system has a fixed format with an educational software environment that cannot be changed. Installing applications or entering the web is not possible.

The pilot program aims at helping schools in making the decision about whether to start using tablet PCs. Schools must make several pedagogical and financial evaluations. This research has two objectives both achieved in separate studies. First, we aim to describe how teachers and directors have adopted the tablet PC for educational use in primary schools. This information can help other schools decide whether to use tablet PCs and inform developers regarding primary schools' needs. The first study highlights the process by which primary schools have adopted tablet PCs in their organizational setting by means of interviews that use diffusion of innovation theory as a guiding framework.

The second objective is investigating primary school children's attitudes towards using tablet PCs in class. Schools have reported both negative and positive experiences with using tablet PCs (Dichev, Dicheva, Agre et al. 2013). An important positive experience is an increase in students' motivation to learn (Clarke and Svanaes 2012; Iwayama, Akiyama, Tanaka, Tamura and Ishigaki 2004; Li, Pow, Wong et al. 2010; Twining et al. 2005). Negative experiences mainly concern the tablet PCs' features, such as short battery life, lack of screen brightness or the vulnerability of the tablet PC (Ifenthaler and Schweinbenz 2013; Twining, Cook, Ralston et al. 2005). Knowing how children evaluate the use of the tablet PC in class and which factors affect this evaluation is important. In the second study, a questionnaire departs from technology acceptance perspectives, but is altered to account for educational settings in which children aged around 8 operate. Although the TAM has been extensively tested and validated among end-users in the business settings, research on its application in education is limited (Teo, Wong and Chai 2008).

2 Theoretical background

2.1 Adoption of tablet PCs

According to Rogers (2003), adoption of a technology occurs in five stages: knowledge, persuasion, decision, implementation, and confirmation. Rogers (2003) distinguishes between three types of knowledge that individuals attempt to absorb: awareness-knowledge, which represents the existence of an innovation; "how-to" knowledge, emphasizing how the innovation is used; and principles-knowledge, concerning the functioning of the innovation. The persuasion stage, in which individuals actively seek information and form a positive or

negative attitude, is followed by the decision to adopt or reject the innovation (Rogers 2003). This decision is affected by several variables, such as support and social influence (Kulviwat, Bruner and Al-Shuridah 2009). In the implementation stage, the innovation is put into practice. Problems can arise and technical support might be required (Rogers 2003). After the implementation stage, adoption or discontinuance are the options in the confirmation stage (Rogers 2003). First, the individual seeks reinforcement for his or her decision, but conflicting messages can reverse the decision (Rogers 2003). The individual will seek supportive messages to prevent dissonance (Rogers 2003). However, when dissonance does occur, an individual can stop using the innovation (Rogers 2003). The final adoption decision is influenced by the perceived characteristics of the innovation, such as compatibility, complexity, observability, and trialability (Rogers 2003), and by adopter characteristics such as organizational structure, strategy, and culture (Frambach and Schillewaert 2002). Furthermore, the social network and the supplier of the innovation influence the adopter's decision (Frambach and Schillewaert 2002; Lind and Zmud 1991; Frambach, Barkema, Nooteboom et al. 1998). Suppliers, for example, target to a specific group, communicate to create awareness and influence perception, and reduce the financial or operational risks (Frambach and Schillewaert 2002).

The first study considers all stages of the adoption process but has a strong focus on the implementation phase because problems can arise at this point and the advantages and disadvantages of using the tablet PC in classrooms become evident. Potential advantages include an increase in students' motivation (Clarke and Svanaes 2012; Li et al. 2010; Twining et al. 2005) and improvement in concentration, communication skills, self-esteem, research, and recoding skills (Twining et al. 2005). Additionally, use of the tablet PC is often natural and intuitive (Twining et al. 2005; Couse and Chen 2010). Couse and Chen (2010) found that children produce comparable quality writing and drawing on tablet PCs and with pen and paper, although children prefer working with tablet PCs. Children with reading difficulties received support from the iPad (Gasparini and Culén 2012). Computer-mediated communication, such as using tablet PC in class, also supports students who suffer from social and emotional shortcomings and often lack support (Eden and Heiman 2011). Tablet PCs can be as effective as using a regular computer for achieving academic goals when used by children with developmental disabilities (Arthanat and Curtin 2013). In addition to increased student motivation, the tablet PC also motivates teachers (Twining et al. 2005), for example by providing immediate feedback (Koile and Singer 2006).

In addition to positive experiences with the tablet PC, negative experiences have also been reported. According to Hulls (2005), using a tablet PC does not have a significant impact on the quality of the course that is offered, according to course grades and teachers' experience. Use of the tablet PC might cause musculoskeletal and visual discomfort, such as back pain and tired eyes (Sommerich, Ward, Sikdar et al. 2007). Technical failures might create frustration and reduce enthusiasm (Twining et al. 2005), such as in the case of limited battery time (Sommerich et al. 2007). To support successful tablet PC adoption, technical and operational issues (e.g. the security of the wireless communication) and providing training should both be managed well (Garfield 2005).

2.2 Children's attitudes towards tablet PCs in the classroom

Organizational innovations are not very useful when the intended target group does not start using the innovation. Well-known theories that explain user acceptance include the Technology Acceptance Model (TAM) (Davis 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh Morris, Davis and Davis 2003). Both theories have been applied to studying the use of tablet PCs in education from various perspectives, such as understanding how students use the tablet PC (El-Gayar and Moran 2007), how the device changes the ecology of the classroom (Culén and Gasparini 2011), and how teachers respond to tablet PCs (Ifenthaler and Schweinberz 2013). These studies have provided several predictors that might affect a child's attitude towards using tablets in the classroom. The technology acceptance model proposes perceived usefulness, or the degree to which a person believes that using a particular system would enhance his or her job performance, and perceived ease of use, or the degree to which a person believes that using a particular system would be effortless (Davis 1989). Both factors contribute to a more positive attitude of the tablet PC or mobile device in general (Bruner and Kumar 2005; El-Gayar and Moran 2007). Therefore, we hypothesize the following:

- H1 Perceived usefulness positively influences a child's attitude towards using the tablet PC in the classroom.
- H2 Perceived ease of use positively influences a child's attitude towards using the tablet PC in the classroom.

Social influence is also known to affect attitudes towards tablet PC use (El-Gayar and Moran 2006; Moran, Hawkes and El Gayar 2010; El-Gayar, Moran and Hawkes 2011). Lai, Wang, and Lei (2012) revealed that support from peers and teachers predict actual usage. In addition, Garfield (2005) confirms that when managers support tablet PC usage, the support available influences successful adoption of the tablet PC. Therefore, we hypothesize that:

H3 Social influence positively influences a child's attitude towards using the tablet PC in the classroom.

Applying the UTAUT model to tablet PCs, Moran et al. (2010) found that experience with a desktop computer affects the acceptance of the tablet PC. Other studies confirm the importance of prior experience when using ICTs (Taylor and Todd 1995). Furthermore, Sommerich et al. (2007) suggest that a positive attitude is associated with the understanding of how to use the tablet PC. Children who already use tablet PCs at home might have a different attitude towards tablet PCs in the classroom. These children are familiar with the technology and therefore might feel more comfortable with using tablet PCs in the classroom. Therefore, we hypothesize that:

H4 Experience with a tablet PC positively influences a child's attitude towards using the tablet PC in the classroom.

When children become familiar with the tablet PC, their independence increases and they require less instruction and assistance (Couse and Chen 2010). Even when technical discomforts increase, independence persisted and children were seldom frustrated (Couse and Chen 2010). Children who use tablet PCs seem to feel confident and independent (Clarke and Svanaes 2012). Children also perceive the PCs as motivating because using them is fun and enables them to work more independently (Clarke and Svanaes 2012). We hypothesize:

H5 Independence positively influences a child's attitude towards using the tablet PC in the classroom.

Using tablet PCs improves children's learning motivation (Iwayama et al. 2004; Li et al. 2010). Tablet PC use increases focus, attention, and motivation, which might also increase the children's interest in the task for which they use the tablet PC. Children between ages three and six using tablet PCs demonstrated a higher interest in tasks, which further increased with age (Couse and Chen 2010). This finding implies that the more positive the child is towards using the tablet PC, the more interesting the task at hand will be to them. We hypothesize:

H6 The interest in the task positively influences the attitude towards using the tablet PC in the classroom.

The influence of the six independent variables proposed (i.e., perceived usefulness, perceived ease of use, social influence, experience, independence, and interest in the task) on a child's attitude towards using tablet PCs in the classroom is tested in general as well as separately for open and closed systems. We question whether predictors differ for both systems.

3 Study 1-adoption of tablet PCs

3.1 Method—sample

Six primary schools in the Den Bosch area participated in a tablet PC pilot program. All six schools are included in the study. The size of schools ranges from 195 to 700 students. One class in each school participated. On average 23.8 (SD=1.6) children are in each class. Three schools used a closed tablet system and three schools used an open tablet system. At the schools with a closed tablet system, every child was provided a tablet PC. The schools using an open tablet system have varying numbers of tablet PCs available, ranging from one per two children to ten tablet PCs that circulate in class. In five schools, we interviewed both the director and the teacher. In one school, we only interviewed the teacher because no acting director was present. The average age of the interviewees was 44.8 (SD=12.7) years. Four were male, and seven were female.

3.2 Method—measures

A semi-structured interview was conducted with questions based on the five adoption phases proposed in Rogers' (2003) Diffusion of Innovation Theory. We asked questions about how participants communicated and gained understanding of the tablet PC (knowledge phase), how participants formed an attitude and gained understanding about possible advantages and disadvantages (persuasion phase), how they chose to adopt or reject an innovation (decision phase), how they implemented the new devices (implementation phase), and their plans for continuing the use of tablet PCs for education (confirmation phase).

The interview also addressed perceived characteristics of the innovation and adopter characteristics, such as the school's size, innovativeness, educational model, and number of students. External variables such as the adopter's environment relate to the influence of others who have already adopted the tablet PC, whereas the social network variable involves questions about the degree of information that is shared between colleagues. Issues regarding the activities the supplier undertook to persuade schools to adopt the tablet PC for education are also considered external variables.

3.3 Method—procedure

Participating directors and teachers were selected and contacted by phone and e-mail. They were told that the interview investigated the process of adopting and integrating the tablet PC in the classroom. When they gave approval for the interview, an appointment was made. The interviews were held in a two-week period and occurred at the school. Permission to record the interview for data analysis purposes was granted. The eleven interviews each lasted from 10 to 47 min. The interviewer used a topic list so that each interviewee was asked similar questions. Follow-up probes were used to ask for elaboration and clarify comments.

3.4 Method—analysis

All recorded interviews were transcribed and coded. Analyses of the interviews was performed in ATLAS.ti 7. For each phase in the adoption process, several codes were extracted and added to the coding scheme. Appendix A contains a table displaying codes, an explanation, and the number of occurrences for each phase.

3.5 Results

Findings of the conducted interviews are presented according to the five stages of Rogers' (2003) diffusion of innovation theory: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation.

3.5.1 The knowledge phase

Table 1 summarizes the topics that emerged from questions regarding the knowledge phase. In four schools, the school board or ICT department raised the director's awareness of the tablet PCs' educational potential. Teachers were then invited to

Code	Subcode	Definition	N total (6)	N closed (3)	N open (3)
Awareness	By board	An umbrella organization for primary schools	4	3	1
	By director	Head of the primary school	2	2	0
	By media	Television, magazines, radio, and newspapers	1	0	1
	By children	The children at school	1	0	1
Interest	Future	Keeping abreast of times	3	1	2
	Motivation	The motivation of children will increase	2	2	0
	Feedback	Teachers gain the ability to provide direct feedback to children	2	2	0
	Tool	Tablet PCs are considered an additional tool	2	0	2
	Cooperation	Children will be able to cooperate	2	0	2
	Lighten work	Teachers will have less administrative work	1	1	0
	PC shortage	School needs more computers	1	0	1
	Replace_Book	Instead of using textbooks and exercise books, children will be able to do their work on the tablet PC	1	0	1
	User friendly	Working with the tablet PC will be easy	1	0	1

Table 1 The knowledge phase and number of schools (closed and open system) to which subcodes apply

participate in a pilot study concerning tablet use in the classroom. In one school, awareness developed from media outings and from several students who use tablet PCs at home. As a result, participants in three schools had an increased interest in staying abreast of current technology changes. Other aspects that triggered participants' interest included the potential increase in students' motivation when using tablet PCs, the possibility of providing direct feedback to children with the tablet PC, decreased administrative work, the availability of an additional educational tool in class, and the ability to stimulate children to work with each other. Some interviewees mentioned their belief that almost all children today are able to work with tablet PCs.

3.5.2 The persuasion phase

In the persuasion stage, people begin actively seeking information and develop a positive or negative attitude towards tablet PCs. Table 2 reveals that the six schools used various information sources, including the organization that delivered the tablet PCs (three schools that later decided to use the closed tablet system), articles in magazines or newspapers, and information found on the Internet. The advantages emphasized in this situation included the possibility of providing direct feedback to children and not having to correct assignments that can automatically be corrected by software on the closed tablet system. The replacement of textbooks and exercise books was also mentioned. Participants in schools that later decided to adopt an open tablet system mentioned that the

Code	Subcode	Definition	N total (6)	N closed (3)	N open (3)
Information	Supplier	Tablet PC suppliers	3	3	0
Sources	Magazines	Magazines, articles and newspapers	3	0	3
	Internet	The Internet	3	0	3
	ICT department	The school's ICT department	1	0	3
	Social influence	Information from others	1	0	1
Expected advantages	Direct feedback	Scores can instantly be returned to students	3	3	0
	Corrections	Less correction work	2	2	0
	User friendly	Device is manageable and user-friendly	2	0	2
	No wires and small	The tablet PC is wireless and small	1	0	1
	Individual or collaborative work	Work can be done individually or collaboratively	1	0	1
	No computers	Computers are no longer needed	1	0	1
	Replacing books	Children no longer work with books	1	1	0
	Position	Teacher no longer stands with back to the class	1	0	1
	No advantages	Participant could not think of any advantages	1	1	0
Expected disadvantages	Vulnerability	Device is vulnerable in the hands of children	3	1	2
	Differentiation	Accounting for individual needs is more difficult	2	2	0
	RSI	Children practice less motoric exercises	1	1	0
	No Internet	Closed tablet PCs lack Internet connection	1	1	0
	Finances	The costs are high	1	1	0
	Distraction	Too many distracting possibilities	1	0	1
	No disadvantages	No initial disadvantages	2	1	1

 Table 2
 The persuasion phase and number of schools (closed and open system) to which subcodes apply

system is small and can be used individually or collaboratively. Respondents most frequently expected the vulnerability of the tablet PC to be a potential disadvantage. Respondents in two school were afraid that the use of tablet PCs made it harder to respect individual needs of children. Physical and repetitive stress injuries, distracting stimuli, and managing the financial aspects were also mentioned as potential disadvantages.

3.5.3 The decision phase

Table 3 lists the decisive factors for implementing the tablet PC in schools. Respondents in two schools mentioned affordability. In two other schools, they

Code	Subcode	Definition	N total (6)	N closed (3)	N open (3)
Deciding factor	Affordability	Using a tablet PC in class is affordable because of the pilot	2	2	0
	Replacement	Replacing computers with tablet PCs	2	1	1
	Addition	Additional tool for educating children	2	0	2
	The future	Children should be prepared for future society	1	0	1
Closed	Control	Teachers lose control in an open system	1	1	0
	Replacement	The closed system replaces traditional work in books	1	1	0
	Development	Open systems are still in development	1	1	0
	Structure	Course materials are unstructured on the open system	1	1	0
	Purpose	The open system lacks a clear educational purpose	1	0	1
Open	Answer book	The closed system is considered nothing more than an answer book	3	0	3
	Society	Tablet PCs should reflect society and need an open structure	2	0	2
	Financial	School cannot afford the closed system	2	2	0
	Creativity	Teachers and children should be creative and critical of content	1	0	1
	Adaption	Responding to the needs of individuals is easier in an open system	1	0	1
Involvement	Director	Directors were involved	5	3	2
	Teachers	Teachers were involved	6	3	3
	Parents	Parents were involved	1	0	1

Table 3 The decision phase and number of schools (closed and open system) to which subcodes apply

were using older computers, which made the decision to adopt tablets easier, particularly because tablets are cheaper than regular desk or laptop computers. When deciding on the closed tablet system or the open tablet system, one teachers mentioned that she feared losing control over children's tablet use on the open system. Furthermore, it is mentioned that educational uses for open systems are still in development, and course materials are still unstructured. Three participants decided to start using the open system because they found the closed system too bound to one method, making it a 'glorified answer book.' They also disliked the inability to differentiate between individual children and the fact that society's open structure is not reflected in the closed system. Children should learn how to use all available information. They believed teachers and children should be stimulated to be creative and critical of content, which is only marginally possible on a closed tablet system. The final adoption decision was mainly made by directors and teachers. Parents were largely left out.

3.5.4 The implementation phase

Results regarding the implementation phase are summarized in Table 4. The closed tablet system was used for about an hour each day. It was used on a daily basis for math in all three schools. In two schools, the closed system was also used daily for language studies. It was used to replace textbooks and exercise books except for one school where it provided teachers the ability to administer extra assignments after the regular work was completed. The duration of open-system tablet use varied. Some teachers used the open tablet system two or three times per week, and others used it for an hour and a half daily. The open tablet system was used for math, grammar, and language lessons, but also offered additional possibilities, such as history, geography, science, or even drawing courses.

All six schools generally reported a positive attitude towards working with the tablet PCs. Teachers using tablet PCs in their classrooms experienced noticeable advantages and disadvantages. Two important advantages can be observed. The first is the increased enthusiasm among the children working with the tablet PC. Secondly, children who find it difficult to concentrate or have socio-emotional problems (for example a minor form of autism) seem to work faster and have improved concentration, among others because they do not have to switch between different textbooks. Two schools working with the closed tablet system and one school working with an open system, specifically noted reduced correction work as important advantage. Additional advantages that users of the closed system experienced include the elimination of the need to switch between textbook and exercise books, the ability for children to process more information, and the ability of teachers to provide direct feedback. Parents can also see how their child is scoring on various subjects. Participants using an open tablet system specifically claim advantages of mobility. For example, the tablet PC can be taken outside where children work on assignments. These teachers also mentioned the potential to easily share information in class and between children. When children work on a tablet PC together, they are more motivated and can learn from each other.

Experienced disadvantages at schools that used the closed system are limited storage capacity and the fact that children need time to become familiar with the tablet PC by means of finding the letters on the keyboard and dragging items. Furthermore, the closed system cannot access the Internet. Children with dyslexia experience difficulties regarding the size of the closed tablet PC, which makes remembering words and finding the letters on the keyboard difficult for them. Participants working with the closed tablet system also mention the vulnerability of the tablet PC. An issue that came up regarding the open system tablet PC is the children's posture. Children sometimes complain about neck or back pain. For teachers, moving away from traditional ways of working is sometimes scary. Having to make time to learn how to use the open tablet PC in their educational curricula is considered a disadvantage. A more technical problem concerning the open system is the fact that applications requiring Flash software cannot be used (iPads).

3.5.5 The confirmation phase

In the final stage, participants can proceed using the tablet PC for educational purposes or stop using it (see Table 5). With the exception of one participant, all respondents

Code	Subcode	Definition	N total (6)	N closed (3)	N open (3)
Use	Math	The tablet PC is used daily for math	5	3	2
	Grammar	The tablet PC is used daily for grammar	4	3	1
	Language	The tablet PC is used daily for language study	3	2	1
	History	The tablet PC is used for history	1	0	1
	Science	The tablet PC is used for science	1	0	1
	Drawing	The tablet PC is used for drawing	2	0	2
	Reading	The tablet PC is used for reading comprehension	1	0	1
	Extra	The tablet PC is used after regular work	1	1	0
Evaluation	Positive	The experience of working with the tablet PC is positive	6	3	3
Advantages	Motivation	Increase in student motivation	6	3	3
	Improvement	Children with socio-emotional problems show improved results	6	3	3
	Correction	Less correction work	3	2	1
	Process	Children process more work	3	3	0
	Feedback	Direct feedback to children	3	3	0
	Switching	No switching between text and exercise book	2	2	0
	Adaption	Assignments based on prior scores	1	1	0
	Parents	Parents can follow child's progress	1	1	0
	Enthusiasm	Enthusiastic teachers	1	1	0
	Mobility	The tablet PC can be taken everywhere	1	1	0
	Sharing	Students can share study material with each other	1	0	1
	Playful	Children learn in a playful way	1	0	1
	Cooperation	Children cooperate and learn from each other	1	0	1
	Easy	The tablet PC is easy to work with	1	0	1
Disadvantages	Storage	Difficulties regarding storage capacity	4	3	1
	Keyboard	Time required to become familiar with touch keyboard	3	3	0
	Sun	When the sun shines, children cannot read their tablet PC screens	2	1	1
	No internet	Tablet PCs cannot access the Internet	2	2	0
	Less writing	Children write less because of the tablet PC	2	2	0
	Malfunction	The tablet PC malfunctions	2	0	2
	Charging	Difficulties regarding charging	1	1	0
	Dyslexia	Children with dyslexia experience difficulties	1	1	0
	Vulnerable	Devices are vulnerable in the hands of children	1	1	0
	Touch screen	Difficulties with the touchscreen's reaction	1	1	0
	Flash	Flash software is not supported	1	1	0
	Conflict	When children work in pairs with one tablet PC, conflicts arise	1	0	1

Table 4	The implementation phase	and number of schools	(closed and open system) to	o which subcodes apply

Code	Subcode	Definition	N total (6)	N closed (3)	N open (3)
	Scary	Teachers scared to use apps instead of the textbook and exercise book	1	0	1
	Time	Adapting to new tool requires time	1	0	1
	Posture	Complaints about child's neck and back pain	1	0	1

Table 4 (continued)

seemed satisfied with their choice concerning the open or closed system. Only one participant decided not to continue after the pilot. They used a closed system of which they felt the costs did not outweigh the benefits.

4 Study 2-children's attitude towards using tablet PCs

4.1 Method—sample

The second study investigated which factors affect a child's attitude towards using the tablet PC in the classroom. Now the children at the primary schools where teachers and directors participated in the first study were questioned in a survey. A total of 139 children filled out the questionnaire (53 % female). The average age of participating children is 8.4 (SD=1.0).

4.2 Method-measures

The questionnaire contained several items to measure the six independent variables and one dependent variable. Demographic features such as gender and age were also collected. Children aged around 8 experience major developments in their cognitive and social maturation (see discussion). This makes exploring the readability and comprehensibility of the survey essential. We conducted a pre-test among five children at two schools. Based on the pre-tests, some items were adjusted so that they were understandable for children approximately eight years old. The final items and constructs and the corresponding descriptives are summarized in Table 6. The first construct in the survey is *attitude towards using the tablet PC*, measured with a fouritem scale proposed by Venkatesh et al. (2003). *Perceived usefulness* and *Perceived ease of use* were both measured by a six-item scale adapted from Davis (1989). *Social*

Code	Subcode	Definition	N total (6)	N closed (3)	N open (3)
Future	Proceed	Will continue to work with the tablet PC	5	2	3
	Stop	Stop using the tablet PC because closed system is too expensive	1	1	0

Table 5 The confirmation phase and number of schools (closed and open system) to which subcodes apply

Table 6 Descriptives for constructs and items for all children (N=139), children who use the closed tablet system (N=71) and children who use the open tablet system (N=68)

	Overall		Closed system		sed Open tem system	
	М	SD	М	SD	М	SD
Attitude (α =.79)	4.4	0.7	4.5	0.8	4.4	0.7
Using the tablet PC is a good idea.	4.6	0.7	4.5	0.8	4.6	0.6
The tablet PC makes work more interesting.	4.1	1.2	4.2	1.1	3.9	1.3
Working with the tablet PC is fun.	4.7	0.7	4.6	0.9	4.8	0.5
I like working with the tablet PC.	4.5	0.9	4.4	1.0	4.5	0.8
Perceived usefulness (α =.86)	3.9	0.8	4.1	0.8	3.7	0.8
Using the tablet PC can enable me to accomplish tasks more quickly.	3.7	1.1	3.9	1.1	3.6	1.1
Using the tablet PC can improve my performance.	3.6	1.1	3.8	1.1	3.4	1.1
Using the tablet PC can make it easier to do my tasks.	4.3	1.0	4.5	0.9	4.2	1.0
Using the tablet PC in my job/school can increase my productivity.	4.0	1.1	4.3	1.0	3.7	1.2
Using the tablet PC can enhance my effectiveness.	3.4	1.1	3.5	1.1	3.3	1.1
I find the tablet PC useful in my job/school.	4.3	1.0	4.3	0.8	4.2	1.1
Perceived ease of use (α =.78)	4.2	0.6	4.0	0.6	4.4	0.5
Learning to use the tablet PC was easy for me.	4.4	0.8	4.3	0.9	4.4	0.7
I find it easy to get what I need from the tablet PC.	3.5	1.1	3.1	1.0	4.0	0.9
My interaction with the tablet PC is clear and understandable.	4.6	0.7	4.6	0.7	4.7	0.6
I find the tablet PC to be flexible to interact with.	4.2	0.9	3.9	0.9	4.5	0.7
It is easy for me to become skillful at using the tablet PC.	4.2	0.9	4.1	0.8	4.3	0.9
I find the tablet PC easy to use.	4.3	0.9	4.1	1.0	4.5	0.6
Social influence (α =.73)	3.5	0.7	3.7	0.6	3.2	0.8
I heard successful stories about using the tablet PC for learning from classmates.	3.3	1.3	3.7	1.2	2.9	1.2
Peers share useful information regarding the tablet PC.	4.0	1.0	4.4	0.8	3.5	1.0
Peers share strategies for using the tablet PC for learning.	3.0	1.3	2.9	1.3	3.1	1.3
I have friends from whom to seek advice on using the tablet PC for learning.	3.3	1.2	3.5	1.1	3.1	1.2
I have friends from whom to seek technical help.	4.0	1.1	4.4	0.8	3.7	1.2
My teachers often use the tablet PC for learning.	3.4	1.4	3.7	1.4	3.0	1.4
My teacher encourages using the tablet PC for learning.	3.3	1.2	3.7	1.1	3.0	1.2
Independence (α =.69)	3.8	0.9	3.9	0.9	3.7	1.0
When completing assignments on the tablet PC, do you need less help from the teacher than when making assignments from the book?	3.9	1.2	3.8	1.2	3.9	1.2
Do you have fewer questions for the teacher when you complete assignments on the tablet PC than when you complete assignments from the book?	3.8	1.1	3.8	1.0	3.8	1.2
Do you complete more assignments with a tablet PC than in an exercise book?	3.8	1.3	4.1	1.2	3.4	1.3
Interest task (α =.85)	3.1	0.9	3.4	0.9	2.8	0.8
I usually have fun doing schoolwork.	3.3	1.4	3.7	1.4	2.9	1.3
I usually enjoy learning at school.	3.5	1.3	3.9	1.3	3.1	1.2
I usually find school interesting.	3.2	1.3	3.5	1.3	3.0	1.3

Table 6	(continued)
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	Overall		Closed system		Open system	
	М	SD	М	SD	М	SD
I usually get involved in learning.	3.5	1.1	3.7	1.2	3.3	1.1
I usually find time flies in school.	3.3	1.4	3.4	1.4	3.2	1.4
I often daydream instead of thinking about schoolwork.	2.7	1.2	3.0	1.2	2.3	1.0
I am usually bored at school.	3.1	1.3	3.3	1.3	2.8	1.2
I usually wish school would end quickly.	2.3	1.4	2.7	1.5	2.0	1.1

influence was originally measured with an eight-item scale adapted from Lai et al. (2012). We decided to remove one item of the original instrument, namely "I often get ideas from teachers on potential apps to use." Schools using the closed tablet system have fixed apps on the tablet PC. *Independence* was conceptualized through three survey items that measure to what degree children feel independent when using the tablet PC compared to books. *Interest in the task* was measured with the intrinsic satisfaction scale adapted from Duda and Nicholls (1992). This scale measures how satisfied or bored children are with schoolwork. Finally, experience with the tablet PC is conceptualized by asking if children have a tablet PC at home (no/yes), which was confirmed by 68 % of the children. The internal consistency of the measures was above aspiration level ($\alpha =>.70$).

4.3 Method—procedure

To increase participation, the surveys were distributed in classes during school time. After a short introduction of the researcher, the survey was distributed to the children, and they were allowed to ask questions when needed. The teachers read the survey out loud and explained some of the items in more detail to account for the specific needs of children aged around 8. After completing the survey, children were asked to check whether all questions were answered.

5 Results

Regression analysis was used to test the hypothesized relationships between independent and dependent variables. First, we estimated regression coefficients for the overall model (all children), followed by two separate analyses for children using the closed and open tablet systems. From Table 4, we can conclude that attitudes towards the tablet PC are determined by perceived usefulness, perceived ease of use, and independence. Social influence, experience and interest in the task do not contribute to explaining the variance in a child's attitude towards the tablet PC. Table 7 also reveals that separate analyses result in different predicting factors. Attitudes towards the closed tablet system are predicted by perceived usefulness and independence. Predictors of

	Overall	Closed system	Open system
	β	β	β
Perceived usefulness	.33***	.51***	.13
Perceived ease of use	.26***	.02	.35**
Social influence	.003	11	.23
Experience	01	.02	00
Independence	.25**	.31*	.22
Interest in the task	.02	.18	20*
$Adj. R^2$.48	.54	.49

Table 7 Predictors of a child's attitude towards using tablet PCs in the classroom overall (N=139), using closed tablet systems (N=71) and using open tablet systems (N=68)

Note. **p*<.05; ***p*<.01; ****p*<.001

attitudes towards the open tablet system are perceived ease of use and interest in the task. Table 8 summarizes the hypotheses.

6 Discussion

6.1 Main findings

The first study aimed to discover the process by which primary schools adopt tablet PCs for educational purposes. This process originated from the need to keep abreast of changing technology and preparing children for the future. Although the interviews were conducted among a small sample, the results provide several interesting strengths and weaknesses of the process that the uptake of tablet systems follows. Note however, that we do not make an explicit comparison between the two systems. The findings of our study tell us something about the adoption and use of tablets in schools, and provide valuable information to schools who are dealing with similar choices. Both directors' and teachers' motivation to adopt tablet PCs in the classroom was triggered by the potential benefits of using this technology. Most attractive were benefits related to facilitating teaching, such as making it easier to provide instant feedback to children

Hypotheses	Overall	Closed system	Open system
H1: Perceived usefulness	Supported	Supported	Rejected
H2: Perceived ease of use	Supported	Rejected	Supported
H3: Social influence	Rejected	Rejected	Rejected
H4: Experience	Rejected	Rejected	Rejected
H5: Independence	Supported	Supported	Rejected
H6: Interest in the task	Rejected	Rejected	Supported

and stimulating children to cooperate with each other. However, early in the adoption process, several hesitations also surfaced. For example, some participants questioned the durability of a tablet PC in the hands of children, or the required motor skills to use tablet PCs for longer periods of time in class. Information about the tablet PC's possibilities was sought in several places. Schools that eventually chose a closed tablet system were primarily informed by the suppliers, who are known to influence the probability of the presented innovation being adopted (Alshamaila, Papagiannidis and Li 2013; Frambach, Barkema, Nooteboom et al. 1998). We do stress however that schools should not rely solely on suppliers, although the system was evaluated positively. Use of the open tablet system has a large range of possibilities and was also evaluated positively. Schools that implemented an open tablet system considered several sources of information before deciding to participate in a pilot. A remarkable finding is that parents were not asked for their opinions regarding use of tablet PCs in class. Social influence also did not seem to matter, which might change after more schools start adopting tablet PCs (Sneller 2007). The ability to participate in a pilot project was a decisive reason to adopt tablets for participating schools because it was financially attractive. Overall, decisions to adopt are made more quickly when the innovation is first used on a trial basis (Rogers 2003).

Both teachers and directors were generally pleased with their experiences with the tablet PC. Important advantages that directors and teachers noticed were an increase in enthusiasm among children, which is consistent with the results of previous studies (e.g., Clarke and Svanaes 2012; Iwayama et al. 2004; Li, et al. 2010; Mouza 2005; Twining et al. 2005). Use of the tablet system improves a child's active participation in class (Agostini, Biase and Loregian 2010). Increasingly, text- and exercise books are considered outdated for children living in a digital world. Increased motivational levels also seem to result in improved concentration, which in turn improves the ability of children to keep up with the rest of their classmates. Previous studies confirmed that computer-mediated communication is an appropriate means to communicate with students who suffer from social and emotional shortcomings (Clarke and Svanaes 2012; Eden and Heiman 2011). Due to the use of the tablet PC, children are less distracted by pencils, gum, books or other materials and seem to focus better on the assignment at hand. An advantage of the closed system tablet is providing children with direct feedback (see also Koile and Singer 2006) and providing teachers with more time to help children and prepare lessons. Furthermore, children process more work than they would without using the closed tablet PC. In schools that used an open tablet system, it was revealed that children work together more frequently. Furthermore, the teaching possibilities are limitless because of the Internet connection and the ability to install additional applications. Limited functionality is the most important disadvantage of the closed system. The closed tablet system lacked Internet access, which is a decisive factor in user dissatisfaction with them, according to Fister and McCarthy (2008). Sommerich et al. (2007) also mentioned dying batteries as an important limitation, although this was not the case in this study. Furthermore, some children using the open system complained about back and neck pain. Sommerich et al. (2007) mention physical discomfort, including headaches or shoulder, neck or back pain, and visual discomfort, such as tired eyes, as

important limitations. Adjusting desks, using ergonomic devices or separate keyboards when using the tablet PC may ease some of these discomforts. In any ways, the learning environment should be properly managed and facilitated to realize the tablet's potential. Henderson and Yeow (2012) furthermore stress that schools need a plan for managing things like recharging batteries, application deployment, backups, and protecting, repairing and replacing tablets as needed.

Our study showed several advantages of both the closed and open tablet systems. Although our interviews are based on a small sample, we feel comfortable in suggesting that suppliers might design a tablet PC that combines the best of both systems. It seems that an ideal tablet PC includes the educational software of the closed tablet system with the ability to extend functionality by installing applications. Furthermore, publishers might start offering educational applications in addition to the traditional text and exercise books. Such a technological shift seems to satisfy educational needs of children, teachers and directors. The advantages the tablet PC has over traditional educational material are promising. Primary school children are more motivated and children with social emotional problems are better accounted for.

The second study was administered to determine which factors affect children's attitudes towards using tablet PCs in the classroom. Children aged around 8 grow and develop rapidly, and increasingly have access to technology as a learning tool (Couse and Chen 2010). Researchers and educators in the field of early childhood education highlight the importance of the children's active use of technology in making decisions, in writing and drawing, and in logical thinking to solve problems (Couse and Chen 2010; ISTE 2007). Factors that affected the general attitude towards tablet PCs are perceived usefulness, perceived ease of use, and independence. El-Gayar and Moran (2007) confirmed the applicability of TAM on students' acceptance of the tablet PC. If necessary, children's attitudes towards tablet PCs in the classroom can be improved if policy makers or teachers could explain the diverse educational possibilities. Perceived ease of use can be increased by preventing technical problems such as storage problems or by adding Internet access to closed systems. As suggested by Couse and Chen (2010), when children become more familiar with the tablet PC, their independence increases, and they require less assistance.

Although social influence is known to impact technology use (Fulk, Schmitz and Steinfield 1990), we did not find a significant effect. A possible reason might be that using the tablet PC in class is mandatory in this study. When using the tablet PC voluntarily, social influence is much more significant than when tablet PC use is required (Moran et al. 2010). Furthermore, children that used the open system often worked in pairs. This way, potential effects of social influence might be neutralized, although we did not find an effect for both systems.

The lack of significant influence from experience can be explained by the ease of use of the tablet PC. It did not matter whether children already used a tablet at home. Interviewed teachers claimed that children became familiar with the tablet PCs very quickly and naturally. The tablet PC is perceived as an easy-to-use device for educational purposes, making prior experience less decisive (Dündar and Akçayır 2014; El-Gayar et al. 2011; Twining et al. 2005). Overall, interest in the task also did not affect attitudes, possibly because tablet PCs themselves increase a child's motivation to learn, despite the topic being taught (Clarke and Svanaes 2012; Iwayama et al. 2004; Li et al. 2010; Twining et al. 2005). Teachers interviewed in the first study observed an increase in children's enthusiasm for learning when using the tablet PC.

6.1.1 Limitations and future research

This research contributes to the body of knowledge regarding the adoption and use of the tablet PC for educational purposes. The decision to adopt a tablet PC involves financial and pedagogical considerations. The results from this study suggest that schools and children support the use of tablet PCs for education. However, the results also suggest there is room for improvement. Both studies have some limitations that should be accounted for in future studies. First, this research was conducted in six primary schools that used the tablet PC in different ways, from considering the tablet PC as an additional tool to replacing textbooks with tablet PCs. Furthermore, the number of tablet PCs available in each class differed. Although such differences do provide a good reflection of how the tablet PC is used by schools in general, future studies might focus on specific situations in which the tablet PC flourishes best in the classroom.

The second study used survey methodologies among children aged 8. Based on studies conducted in the Netherlands, De Leeuw (2005) stressed that the age of 7 is a major developmental point in the cognitive and social maturation of children, and that from this age they can be surveyed directly in surveys simple both in question structure and question wording (e.g., ambiguity and vagueness). Careful pretesting should always be done to decide whether the questioning is understood, and an informed parent or daily caretaker can serve as a proxy respondent and provide additional information (De Leeuw (2005). Although we did our utmost best to adapt the phrasing of the items to the specific age group, conducted pre-tests to make sure that the questions were understandable for the intended age group, and provided additional information and explanation by the teachers, we do stress that additional studies might further strengthen the validity of our results. Especially since young respondents between age 8 are far from a homogenous group, and differ in their cognitive development, memory speed and emotional and social development (De Leeuw 2005). Ideally, questionnaires should be tailored to the cognitive and social maturity of each child (De Leeuw 2005).

In the model to explain a child's attitude towards using a tablet PC in school, three factors appeared significant, together explaining 47.3 % of the variance in a person's attitude regarding the tablet PC for educational use. Future studies should investigate additional factors that might affect children's attitudes. For example, Bruner and Kumar (2005) suggested fun as a positive determinant for attitude towards handheld devices. Studying students' needs has also been proposed (Lai et al. 2012). Future studies should add these factors to the model to gain a more comprehensive picture about a child's attitude towards tablet PCs.

Finally, some findings in the second study require additional clarification. For example, for open tablet systems, it appeared that interest in the task had a negative influence on attitude. This finding suggests that when interest in schoolwork increases, attitude towards using the open tablet PC decreases, which might indicate that children prefer textbooks and exercise books and find an open system tablet PC distracting. Under what circumstances would this effect appear?

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