A SYSTEMATIC REVIEW OF LEARNING AND TEACHING WITH TABLETS

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ABSTRACT

Due to the increased popularity of tablets in schools, this systematic review examines the literature on tablet-mediated learning attempting to identify how tablets support the emergence of new teaching and learning practices as well as the transformation of existing ones in primary and secondary schools. 39 studies were selected using predefined selection criteria, most of which concern natural sciences, math and language. The result identified 10 themes of pedagogical teaching and learning practices that are supported by tablets in schools, namely: augmented and virtual learning, collaborative learning, communication, documentation, feedback and assessment, game-based learning, individualized learning, inquiry-based learning, mobile learning, and multimodal learning. The identified themes of practices support and interact with each other to serve learning and teaching purposes.

1. INTRODUCTION

Though envisioned by Microsoft already in 2002 (Dray et al, 2002), the tablet computer (tablet PC or tablet) hadn't appealed the public's attention until Apple's release of iPad emerging as the "category-defining blockbuster" of tablets (Pregum et al, 2013). The ownership of tablets has grown greatly since then. By 2013, one third (34%) of American adults had a tablet computer (Zickuhr, 2013).

This popularity of tablets has even extended to schools since 2010 (Henderson and Yeow, 2012). iPads, in particular, being widely adopted in educational settings around the world are the most popular handheld learning device in the schools (Pegrum et al, 2013). Many counties are looking in-depth into the usage of tablets for educational purposes. Apple and ConnectED, an initiative by President Obama, donated an iPad to every student, a Mac and iPad to every teacher for 114 schools across the States (Apple and ConnectED, 2016). Almost 70% of primary and secondary schools in the UK now use tablet-computers to assist learning (Coughlan, 2014). Ontario in Canada announces $150 million investment for iPads in the classrooms (Rieti, 2014). A Chinese company, Shenzhen Scope Scientific Development, has signed a contract for the provision of 400,000 tablets for students (Clarke & Svanaes, 2013). In Sweden, many schools have made tablets available and free of charge for young pupils (Nouri & Cerratto-Pargman, 2016; Bergström & Höglund, 2014).

The research has shown that tablets indeed have promising potentials in facilitating the learning process for pupils of different ages and needs (Cerratto-Pargman, Nouri & Milrad, 2017; Li et al., 2016; Lee, 2015; Gasparini & Culén, 2013; Henderson & Yeow, 2012). For instance, the study of Nouri & Cerratto-Pargman (2016) demonstrated how tablets support teaching and learning practices in Swedish schools through three affordances, i.e. persistence of the digital medium, multimodality of the content and portability and ubiquity. They also discovered that tablets support six themes of learning and teaching practices, namely, organization of teaching and learning, documentation, communication, multimodal learning, assessment and formative feedback, and mobile learning.

Despite of the increased attention and use of tablets in education, previous literature reviews, such as Cobcroft (2012) and Wu et al (2012), have focused mainly on analysis of mobile learning by handling all mobile technologies, that is to say, tablet, portable notebook, smartphone and PDA as one bundle. The reviews focusing on tablets, such as Nguyen et al. (2015), investigated on how iPads have been adopted in

the higher education. The literature review by Haßler (2015) is the only review with a focus on the use of tablets by pupils in primary and secondary schools across the curriculum. However, while Haßler's study provides a useful overview on learning outcomes by using tablets, it does not shed light on the teaching and learning practices aided by tablets. Therefore, the significance of this paper is to deepen the understanding on how tablets support the emergence of new teaching and learning practices as well as the transformation of existing ones. This study adopts the systematic review method to close this gap and aims to answer the question "How are pedagogical practices supported by tablets in primary and secondary school?"

2. METHODOLOGY

2.1 Data Collection

2.1.1 Database

The study searched databases that are known for education and information technology: ACM (Association for Computing Machinery), Elsevier Science consisting of Computers & Education, ERIC (Education Resources Information Center), JSTOR consisting Journal of Educational Technology & Society, IEEE (Institute of Electrical and Electronics Engineers), Science Direct consisting of Computers in Human Behavior, SAGE Journal Online, The International Review of Research in Open and Distance Learning, Wiley online library consisting Journal of Computer Assisted Learning, Inderscience Online consisting International journal of mobile and blended learning.

2.1.2 Keywords and Search Terms

The keywords are tablets, iPad, Android tablets, education(-al) app(-lication); education, primary school, elementary school, junior school, middle school, secondary school, high school, pupils, students, teacher, instruction, learning, teaching.

The keywords were combined to form search terms (e.g. "iPad learning high school"). Whenever applicable, Boolean logic was used for constructing search terms (e.g. "tablet" OR "iPad"). When a database didn't allow Boolean logic, individual combinations of the keywords were searched in the databases. The search result generated a large number of studies (>500). Only the articles that were screened by the inclusion and exclusion criteria were selected for this systematic review.

Table 1. Selection Criteria

Inclusion criteria	Exclusion criteria
Formal education from primary school to secondary school	The use of tablets in higher education, informal education (e.g. home learning) or pre-school education
Empirical studies (observation or experimentation) relating to the utilization of tablets in education	Studies not investigating on the physical use of tablets in teaching and learning practices, such as acceptance, attitudes or learning outcomes
Time period from 2010 to 2017	Studies not solely focusing on tablets, such as the use of other mobile devices like smartphone and laptop
Studies with an abstract	

This systematic review intends to investigate the usage of tablets in formal education of primary and secondary school. That excludes pre-schooling and higher education. Besides, this review solely studies tablets, which implies that studies on smartphones and other mobile devices are not considered. The focus of this review is to examine how tablets are engaged in teaching and learning. Other factors like learning

outcomes are not the primary concern. The iPad's success in 2010 caught the public attention. Therefore, the search covers the time period from 2010 until now. At last, only articles with an abstract are eligible.

2.1.3 Data Extraction

A data extraction form was designed. The pilot form was refined several times to ensure the quantity and quality of data. Each paper was scrutinized for the following data: general information including source and year of publication, area, context; study characteristics including methodology/study design, sample size; result and research reliability.

2.1.4 Data Analysis

This paper was guided by procedures from content analysis (Braun & Clarke, 2006) in order to code the selected studies. The coding approach was inductively performed to identify the categories of learning and teaching practices supported by tablets. The coding resulted in 10 categories of practices. 20 out of the 39 papers (50%) were coded independently. The inter-rater reliability (r) was 0.92, a good agreement between the two coders.

3. RESULT

3.1 Geographic Distribution of the Selected Studies

The articles examined were published between 2010 and 2016. The research was carried out though out the world, though especially popular in Asia (16 studies) and Europe (12 studies). Interestingly, only 3 studies were found in North America. iPad, an American product, has been given a fair opportunity to be engaged in the American education, such as Apple's effort in donating a large amount of iPads to students and teaching staff (Apple and ConnectED, ibid). The result also shows that the majority (28 studies) of the research was conducted in primary schools while 9 studies in secondary schools. Generally, tablets are used within the classroom (33 studies). The mobility does allow students to carry it outdoors for learning purpose or bring it home. It may imply that a classroom is still the most common learning environment for school education. Another finding is that tablets mostly interest Math (8 studies), Natural Science (10 studies) and Language study (11 studies). Other subjects engage tablets less frequently.

3.2 Tablet-mediated Teaching and Learning Practices

Table 2 below presents the 10 identified categories of tablets-enabled teaching and learning practices. Some studies are listed under different categories as they engage tablets in different pedagogical practices.

3.2.1 Augmented and Virtual Learning

Augmented reality (AR) offers an interface composing of digital information and visualizations blended with physical reality. It allows users to interact with both real and virtual worlds by a tangible interface (Hsu et al, 2015). The app "Video Physics" is introduced to teach motion and velocity (Lohr, 2014). Students film a moving object with the tablet's camera and open it in "Video Physics" so that the position of the moving object can be marked frame by frame through tapping on the object. "Video Physics" then displays the path of the object and drew graphs of the position and velocity of the object. Some physics experiments are conducted through Google Glass's AR (Kuhn et al, 2016). AR provides an alternative to experimental equipment (Grubelnik, 2016). In order to determine the gravity acceleration of a falling body, students record a video of a falling body and use the app "Tracker" to analyze the physical dynamics. None of the tradition physical equipment is needed to measure the acceleration. Furthermore, AR assists leaning in social science as well. Aurasma, an augmented reality software giving students access to the historical videos when reading a textbook, helps student to study history in Hsu's (ibid) experiment. Whenever a student reads the textbook and is interested in a historical figure, s/he can scan the picture with the tablet and the corresponding video of the figure then is played on the screen.

Virtual reality functions in a similar fashion, in form of a substitution of tradition experimental equipment. The app iCircuit is an electronic circuit simulator, which allows students to build electric systems using predefined building blocks just like working with real circuit units (Lohr, ibid). Moreover, it is common that VR enables 3D operation interface on a 2D screen. Chinese calligraphy learners can practice the right stroke order through 3D writing process on a 2D screen on the app "Unity3D", which is a virtual reality-based version of spatial abilities assessment instrument (Wu et al, 2013). Similar apps are utilized in a virtual chemical laboratory (Uchiyama, 2013).

Table 2. Overview of Categories of Pedagogical Practices and Articles (Note: Article Numbers are Referred to the Numbering in Appendix)

Category	Description	Article nr.
Augmented and virtual learning	Learning through augmented reality	11,16,18,29,37
	Learning through virtual reality	27,35,38
Collaborative learning	Knowledge procurement and construction through collaboration: sharing the physical device, planning, discussing, negotiating, solving problems and exchanging opinions.	1,2,8,9,15,25,33
Communication	Communication takes place between teachers and pupils, among pupils online face to face or through virtual environment such as Skype and Google Docs.	9,15,25,27
Documentation	Tools to make markings and important annotations, taking photographs, audio and video recordings, drawing etc.	7,15,17,22,32
Feedback and assessment	Teachers monitor learning process, comment and assess the work using digital feedback systems.	13,14, 19,33,34
Game based learning	Learning through playing digital games.	4,15,24,33,36
Individualized learning	Students learn new content on their on pace and/or by themselves. Tailored difficulty levels in apps.	3,15, 21,27,26
Inquiry based learning	Learning through inquiry. Using the tablet for data collection.	11,15,33,37,39
Mobile learning	The portability enables learning at any given location in the classroom and outdoors.	7,15,17,22,37
Multimodal learning	Learning through different modalities (sound, image, text, video, etc.)	1,2,3,7,8,10,12,22,23, 27,28,39,30,31,32
	eBooks.	3,5,6,15,20,27
	Educational apps (non-game)	1,2,3,7,10,12,19, 22,23,27,32,39

3.2.2 Collaborative Learning

Tablets can facilitate collaborative learning. Tablet-mediated tasks require debates and negotiations, team research and outcome presentations. Students learn to create newsletters in pairs by assigning team roles, searching information online and producing an animated poster (Culén,2012). In order to learn English

collaboratively, students need to create and construct digital language productions within their group (Alhinty, 2014). Both studies show that, through tablets, learning can be collaborative and production-based. When combined with external equipment or services, tablets provide more means of collaborative learning. Fallon (2015) examined cloud services such as Google Docs that is characterized by its convenience of synchronicity. Google Docs enables students to share work and allows them to edit, add content or correct each other's mistakes. Several people can work on the same output concurrently. Furuya (2016) tested CSCL (Computer Supported Collaborative Learning) app "edutab". Students write solutions to Math questions in the app, which are later displayed on an LCD screen. In this case, students can see others' solutions, it inspires ideas and encourages exchanging opinions. Mobility and flexibility of tablets are also factors to smooth the collaborative learning (Fallon, ibid). The size of display allows a group to view the same content at the same time. It can be easily repositioned, angled or rotated for different purposes such as viewing YouTube clips. Students can help others or ask for help by being able to carry the device easily to different parts of the classroom or into another environment.

3.2.3 Communication

Supported by hardware infrastructure like Wi-Fi or cellular network, communication can take place at anytime and anywhere through tablets. The communication covers both teacher-learner and learners with their peers. According to Alhinty (2014), online communication is enhanced by the mobility and instant accessibility provided by tablets. The students, through iPad blogging, can meet their classmates virtually, hence, to discuss their learning experience. There are other alternatives to realize virtual communication. For example, Edmodo, Skype, iMessage as well as Google Docs provide audio and video face to face, real time communication (Nikolić, 2013). Edmodo, an application similar to Facebook, makes communication between student and teacher much simpler and faster at all times.

3.2.4 Documentation

Tablets affordances expand the forms of documentation further than pen and paper's reach. Typing text and entering content digitally on tablets are environmentally friendly and don't require physical pen and paper. Photographs, voice recording and videos are convenient and useful tools for documentation, shown in Geer et al. (2017) and Alhinty's (2014) study. The camera and photo can easily document objects that are fragile or hard to move within school or bring to school. Apps like Puppet Pals allow young learners to make the characters image by photographing and to make the characters talk by recording their own voices. However, learners do prefer certain types of documentation methods. Wyeth et al (2011) conducted a study to test typing, recording and drawing for ecological observation and data collection. It was reported that learners found drawing more difficult to use compared to the other two. But this doesn't imply that sketching and drawing stand on disadvantage in all scenarios. Wang et al (2013) considered sketching advantageous for learning. Students, instead of reading information or typing notes on the tablets, were asked to sketch out the image and their impressions on what they have seen and learned from a specific cultural context in a museum. The sketches on tablets were presented and discussed later in a regular classroom. Wyeth et al (ibid) believe that all these new ways of documentation encourage learners to explore different forms of expression. The expressive use of these affordances leads to media-rich work and authentic experiences that accommodate student-centered pedagogies and authentic learning.

3.2.5 Feedback and Assessment

Several studies investigated feedback and assessment through tablets. The common factor in the studies is that tablets are the host for various digital learning platforms. Students' answers or performance are submitted or monitored through tablets. Sun et al (2016) examined iFIT (Interactive, Feedback-based In-class Teaching system). Each member of a learning group in turn uses the tablet to deliver a response, which is sent to a server. The teacher views each student's response on a control screen and analyses the responses of the entire class. Earlier, Harfield et al's study (2013) presented a similar system called Open Monitoring Environment (OME). The OME captures the state of the learning progress of students' though complex visualization on a tablet's screen, which can offer teachers insight on students' progress and difficulties. The teachers can monitor all the students' activities such as ongoing problem solving or finished tasks. Being provided by graphical visualizations of the analyzed data, teachers are able to interpret the visualized information, see indications of students' learning and thereafter adjust their teaching. Another e-learning platform, Moodle, is also used for giving feedback to students by allowing students to upload their work, which is commented and assessed by the teacher (Lohr, 2011).

3.2.6 Game Based Learning

The game based learning materialized through tablets mainly focuses on developing mathematics and literacy skills. Henderson et al (2012) and Culén et al (2012) believe that playing digital games on tablets can reinforce the learning of math while spelling games are widely used for literacy development. Walubita's team (2015) also confirmed the literacy part. They installed GraphoGame on students' tablets, which is an evidence-based computer game that helps early grade learners to master the link between letters and their sounds as a foundation to acquisition of reading skills. The result showed that sufficient practice on GraphoGame led to increase initial literacy skills. As to Math, Deckard et al (2014) observed how digital games helped students to deepen the understanding of fractions. They concluded that the game playing shifted learners' focus from achieving the learning goals to advancing levels of the game. The winning intention became the motivation. The game itself was considered as a non-invasive assessment tool, collecting continuous data throughout play sessions. The progress was automatically tracked.

3.2.7 Individualized Learning

The tablet and its flexibility enable autonomous and individualized learning, meaning students can learn in their paces based on their needs and choose the exercises accordingly. For example, in language classes, pupils who are shy and often tend not to communicate can practice speaking at home on the tablet apps recommended by the teacher and then send their voice recordings to the teacher (Nikolić, ibid and Crnković, 2014). It can be a great opportunity for the less self-confident students to build their confidence gradually. Besides, tablets can help achieve a regular contact between the teacher and the student as the teacher gives each student individually feedback on their strengths and areas for improvement. Tablets are considered helpful especially in a group of students with heterogeneous learning abilities (Ramkalawon et al, 2016). It provides students with greater flexibility to proceed with their own pace and to follow their own interests, potentially increasing their motivation to pursue learning opportunities. For instance, apps like as Dragon Dictation or Spelling Notebook are used for practice spelling or pronunciation. Not only do learners have control on the process or revisit learning material as many times as it requires, but also get immediate feedback about their progress. In this case, students can become more aware of their own learning (Crnković, ibid). In a pilot study, students were able to learn faster on their own by repeating lessons as many times as they wished (Nedungadi et al, 2014).

3.2.8 Inquiry Based Learning

In Lohr's (2014) experiment, students conducted physics experiment with AR. The technology did help the students understand the physics process. Meanwhile, tablets provided them an opportunity for inquiry-based learning. The live data recorded by sensors on the tablet could be analyzed step by step according to a "guided tour" with built-in statistical tools like minimum, maximum, mean or standard deviation on the app "SparkVue". Students could disable the guided tour feature and explore the content and solve problem for themselves implementing the inquiry-based learning model. Grubelnik's (2016) observed inquiry based problem solving as well. Students analyzed a given task in astronomy independently with the assistance of tablet and Internet. They retrieved useful and relevant data such as mass of the planets in solar system from research to complete the task. Learners could even creatively combine different apps in ways that were not immediately apparent for solving open-ended research tasks (Mann et al, 2016). For instance, a student used a web browser for searching news and took a number of screen shots, which were opened in Book Creator app and pasted into a new file. In the end, the student marked certain important text digitally as notes.

3.2.9 Mobile Learning

One of the key findings in the result is the important advantage of tablet's mobility. This allows students to execute different tasks in numerous environments. The tablets could move along a free falling object and record data for physics analysis (Grubelnik, ibid). Because of the portable nature and lightweight, learners could carry the tablets around with them, even if not needed. They could move around in the class or change desks (Mann, 2016), which is a perquisite for ubiquitous learning. It was observed by Henderson (2012) that students could easily work in groups and move from one location to the next when needed. For instance, it allowed students to gather around the teacher and used the tablets to follow what was being read to them while looking up definitions of words. Because of this feature, learning can also take place beyond a physically limited classroom. During a culture observation school trip (Wang, 2013), students could the

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record the teacher's instructions on their tablet and draw their impressions onto their e-sketch notes anytime anywhere as means of data collection. Wyeth (idib) organized field trip so that learners could experience and capture observations of interesting environmental attributes they encountered, including plants, trees, birds, insects, spiders, reptiles and mammals and recorded them on tablets.

3.2.10 Multimodal Learning

A large number of the included studies are associated to the utilization of multimodal affordances of the tablets (i.e., sound, image, text).

eBooks or digital books are interactive books that have audio, video and interactivity making content alive. Students first and foremost used tablets as textbook when they answered the question "the functions of tablets in lectures" in Švecová et al's survey (2015). eBooks can be used in many contexts of the classroom teaching. Henderson (ibid) observed that Math teachers converted math textbook in PDF format and uploaded onto the iPad for children to use, while other teachers read parts of a novel daily to students through the iPad's iBook. Students also used the iBook to read individually and for peer reading. Geography teachers made "digital books" that provided students with a lot of visualized content and a variety of multimedia materials in order to study waves (Nikolić et al, ibid). Gong et al (2013) also investigated how eBooks were engaged in teaching and learning. The interactive function of eBooks allowed contents to be projected on a bigger screen through Airplay showing students' products from their iPad, highlighting the texts, and providing instant feedback. They stated that students were highly motivated to use eBooks in learning activities. However, technological issues, such as failures of devices and software, delays of systems response, are still the key obstacles for teachers to use eBooks in the classroom. At the same time, Henderson (ibid) pointed out that more attention must be paid to the professional development of teachers' digital competence in order to master the tablets in teaching.

Almost one third of the selected studies (12 out of 39) reported the usage of educational apps. Geer et al's (2016) survey stated that approximately 40% students used educational apps at least six times a week. According to Mann (2016), the App Store offers thousands of free educational applications for every subject and these multimedia applications featuring interactivity make learning easier. For example, digital editors or spelling apps bear advantages for learning the spelling of words. Students can switch between dictionary app, note-taking app and eBook during reading. The book creator app can produce posters or short comics. 'Super Spellers, Crazy Cursive, Sumdog, King of Maths, Brain Training' are designed to train a specific competence such as literacy or numeracy abilities.

4. DISCUSSION

This review aimed to provide an overview on the pedagogical usage of tablets in educational settings. After applying inclusion and exclusion criteria on more than 500 studies, 39 articles were selected for further analysis. The analysis resulted in the identification of 10 themes of learning and teaching practices that are supported by tablets, namely, augmented and virtual learning, collaborative learning, communication, documentation, feedback and assessment, game-based learning, individualized learning, inquiry-based learning, mobile learning, and multimodal learning.

A number of conclusions can be drawn based on the identification of the 10 themes. First, in research studies, tablets supported a large variety of learning and teaching activities. Second, innovative learning and teaching practices emerged such as augmented and virtual learning. Meanwhile practices like documentation and collaborative learning were enhanced and transformed by tablets. Thirdly, the findings in this review confirmed and further complemented Nouri & Cerrato-Pargman (2016) which studied how students and teachers, without any guidance intervention, used tablets. This shows the consistency between the way tablets are used in research settings by scholars and in educational settings by students and teachers. Fourthly, multimodal learning stands out as one third of the selected studies concern some aspects of multimodal learning.

Furthermore, a couple of research gaps were identified. Few of the learning and teaching activities designed by researchers (and teachers in some cases) in the included studies were informed by theories of learning. Additionally, longitudinal studies were rarely employed. As pointed out, tablets are primarily used in subjects such as language, mathematics and natural sciences. The engagement of tablets in other subjects

in K-12 education like social sciences, music and PE was not sufficiently presented. Future research may focus on determining the obstacles of integrating tablets in those subjects and conducting longitudinal studies of implementing tablets for teaching and learning.

The main limitation of this systematic review is that it primarily aimed at identifying the types of tablet-mediated learning and teaching practices, and overlooked the effectiveness and the efficiency of these practices in terms of learning and teaching.

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