The effects of technology-mediated immediate feedback on kindergarten students' attitudes, emotions, engagement and learning outcomes during literacy skills development

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A B S T R A C T
Two studies were conducted to examine kindergarten students' perceptions of technology use in the classroom, and the effects of receiving immediate feedback versus no feedback while using this technology on their attitudes, emotions, engagement, and learning outcomes in the context of literacy skills development. To assess students' perceptions of technology use in the classroom, structured interviews were conducted. Students then used various tablet applications (apps) that provided or did not provide feedback across various literacy tasks. A repeated measures design was used for both studies. In Study 1, 31 students (16 girls) were interviewed and tested over two sessions in April (8th month of school). In Study 2, a new sample of 33 students (16 girls) was interviewed and tested in two sessions in October (2nd month) and again in two sessions in April. Analysis of interviews revealed that students enjoyed receiving positive feedback, but did not like the negative feedback they received when their answers were incorrect. Analyses of quantitative data revealed that, for Study 1, technology-mediated feedback resulted in lower levels of enjoyment but higher levels of achievement compared to when no feedback was provided. For Study 2, technology-mediated feedback resulted in more boredom and less engagement in October compared to when no feedback was given. By April, however, feedback resulted in less boredom and higher levels of achievement compared to no feedback. Theoretical and pedagogical implications are discussed.

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1. Introduction
In today's educational context, teachers have at their fingertips a multitude of digital technologies that can be integrated into their classrooms. Even though there are a large number of tools that are available today, educational institutions have not fully integrated these technologies into classrooms in ways that can support learning (Collins & Halverson, 2009). Moreover, despite the widespread interest in the use of technology as a tool for learning, research on early literacy development and educational technology has been mixed (Cassady & Smith, 2004; Schmid et al., 2008). Proponents of technology as an instructional scaffold for the development of literacy skills claim that the immediate feedback that applications, such as tablet applications (apps), can provide during learning may enhance engagement, motivation, and learning outcomes. Although studies have shown that students are more engaged and experience higher levels of motivation when using technology compared to more traditional paper-and-pencil methods for learning, this often does not translate to higher levels of literacy achievement (see Schmid et al., 2008; for a review). Given the push in many schools to use technology to support learning, more systematic research is needed to fully understand the role that technology, particularly immediate feedback, plays in the development of early literacy skills.

How might immediate feedback affect learning? According to theoretical models of self-regulated learning (Winne & Hadwin, 1998; Zimmerman, 2000), immediate feedback about one's progress on a task can promote the development of self-regulated learning skills (Butler & Winne, 1995; Muis, 2007; Zimmerman & Labuhn, 2012). Self-regulated learning is defined as “learning that results from students’ self-generated thoughts and behaviors that are systematically oriented toward the attainment of their learning goals” (Schunk, 2001, p. 125). As Zimmerman (2002) noted, self-
regulated learners are more metacognitively aware, more motivated, and generally perform better than less self-regulated learners. Research has shown that students who are better at regulating their learning have higher levels of self-efficacy (e.g., confidence in being able to successfully carry out a task; Zimmerman & Kitsantas, 2007), experience greater interest in a task (Schunk, 1996), and attain higher levels of achievement (Muis, 2008). Immediate feedback serves as a key source of information regarding how well one is performing a task (Butler & Winne, 1995; Zimmerman & Labuhn, 2012) and can serve to improve one's calibration accuracy with regard to the effectiveness of learning processes for successful task completion (Stone, 2000). In particular, immediate feedback provides information concerning goal and learning progress, which sustains motivation and boosts self-efficacy (Schunk, 2003). Furthermore, as previous research has shown, immediate feedback can have positive benefits on cognitive and metacognitive performance, which translates into higher levels of achievement (Corbett & Anderson, 2001; Nietfeld, Cao, & Osborne, 2006; Saadawi et al., 2008).

However, learners (especially younger students) are not very good at self-regulating their learning (Butler & Winne, 1995; Zimmerman & Martinez-Pons, 1990), nor are they accurate with regard to how well they are carrying out a task (Winne & Jamieson-Noel, 2002). Given that kindergarten teachers are more frequently integrating the use of technology that provides immediate feedback during learning (see Schmid et al., 2008), we questioned what effect immediate feedback has on students' attitudes, emotions, engagement, and learning outcomes. That is, the purpose of our set of studies was to explore the role that technology-mediated immediate feedback plays on kindergarten (age 5) students' attitudes, emotions, behavioral engagement, and learning outcomes in the context of literacy skills development. Prior to detailing our study, we first present the theoretical frameworks that guided our work, review relevant research, and end with our specific research questions and hypotheses.

1.1. Zimmerman's cyclical phase model of self-regulated learning

Developed from a social-cognitive perspective (Bandura, 1992; Schunk, 2001), Zimmerman's (2000) cyclical model of self-regulated learning includes three interrelated phases: forethought, performance, and self-reflection. The forethought phase includes self-regulatory processes and beliefs that precede learning. Two central processes that occur during this phase include task analysis processes and self-motivation beliefs. Task analysis includes breaking down a task into key components, which then influences the plans and goals that students make. Given that task analysis requires personal initiative and persistence, a high level of motivation is necessary. As such, students may draw on their sources of motivation such as their self-efficacy beliefs, interest in the task, or value for learning. The plans and goals that students set then predict the processes implemented during the next phase of learning.

The performance phase involves self-regulatory processes that occur during learning and those that seek to control it. The central processes during this phase include self-control and self-observation. Self-control refers to the actual use of a variety of strategies to complete the task, such as task, cognitive, and behavioral strategies. Self-observation refers to metacognitively monitoring or self-recording one's performance phase processes or outcomes. After the performance phase, the self-reflection phase begins, wherein an individual evaluates one's performance and makes attributions of causality regarding the outcomes. Two key processes during this phase include self-judgments and self-reactions. Self-judgments are a type of self-evaluation wherein a learner compares the learning outcome to a goal or standard, or makes a causal attribution with regard to the causes of success or failure. Comparisons of one's performance to a goal or standard may result in satisfaction (a self-reaction), when the goal or standard is achieved, or dissatisfaction, when the goal or standard is not achieved. Self-reactions may then trigger an array of different emotions, ranging from elation or joy when satisfaction occurs, to sadness or depression when dissatisfaction occurs. These self-reactions then influence the forethought processes regarding future efforts and possible outcomes, which completes the self-regulatory cycle. If, for example, an individual experiences high self-satisfaction, motivation (i.e., self-efficacy) increases. In contrast, if dissatisfaction occurs, then motivation may decrease (e.g., Zimmerman & Bandura, 1994; Zimmerman & Labuhn, 2012). Students reflect on their performance based on a variety of processes, including intra-individual comparisons such as contrasting current performance relative to one's prior performance, inter-individual comparisons such as evaluating current performance relative to one's peer's performance, or attributions based on scores on tests (Zimmerman, 2002). Particularly relevant for the latter is performance feedback.

1.2. The role of feedback in self-regulated learning

As previously noted, key to self-regulated learning is feedback during learning (Carver & Scheier, 2000; Muis, 2007; Winne & Hadwin, 1998; Zimmerman, 2000). According to Zimmerman and Labuhn (2012), self-oriented feedback loops refer to processes through which learners monitor the effectiveness of their learning strategies and respond to that feedback via changes in self-perceptions and behaviors. As such, metacognitive monitoring and awareness play a central role in self-regulated learning (Muis, 2007; Pieschl, 2009; Winne & Hadwin, 1998). To effectively regulate one's learning, it is essential for a learner to be aware of whether he or she knows something, which is also known as calibration (Nietfeld et al., 2006; Pieschl, 2009; Schraw, 2009). Calibration refers to the degree to which learners' self-judgments about their capability or learning outcomes accurately reflect their competence (Pieschl, 2009; Schraw, 2009). Studies have shown that better calibration accuracy is related to metacognitive skills and higher levels of achievement (Butler & Winne, 1995; Nietfeld & Schraw, 2002).

Bandura (1986) proposed that more accurate calibration is pivotal for academic achievement. That is, better self-regulation of learning occurs when learners can effectively monitor and evaluate their progress accurately and therefore make adaptations to learning based on a correct analysis of their performance. Given that students are generally overconfident about their capability of performing on a certain task (Dunlosky & Lipko, 2007; Pajares & Miller, 1997) and that overconfidence is frequently related to lower levels of achievement (Klassen, 2006; Winne & Jamieson-Noel, 2002), approaches to improving calibration are needed. Indeed, several strands of research have developed over the past decade to promote calibration accuracy (e.g., Huff & Nietfeld, 2009; Labuhn, Zimmerman, & Hasselhorn, 2010; Saadawi et al., 2008).

One method by which researchers have attempted to improve calibration accuracy is via immediate feedback (Labuhn et al., 2010; Saadawi et al., 2008). Theoretically, immediate feedback from an external source like a teacher, peer, or computer-generated feedback, provides learners with information about how well they are performing (Butler & Winne, 1995) and may prompt learners to assess their progress on a learning task. Outcome feedback is typically generated externally, and is based on performance measures (Stone, 2000). As Labuhn et al. (2010) argue, this type of
feedback does not inform students how to self-regulated their learning, but it does initiate self-regulatory processes. When this occurs, students may become aware that they are not progressing as expected and may then adjust learning accordingly (Butler & Winne, 1995). Moreover, as Winne (1997) proposed, learners need practice with feedback, and this can be achieved by providing continual feedback during completion of learning tasks.

For example, Saadawi et al. (2008) examined the effects of continual immediate feedback on metacognitive performance and learning outcomes with a sample of university students, and investigated whether metacognitive scaffolds fostered metacognitive gains when immediate feedback was faded. Immediate feedback was provided via an intelligent tutoring system. Results revealed that immediate feedback had significant positive effects on calibration and learning outcomes compared to a control group. However, despite gains with continual immediate feedback, the researchers found that when immediate feedback was faded, participants' metacognitive performance declined even when other metacognitive scaffolds were still provided. In another study, Labuhn et al. (2010) examined the effects of feedback on calibration accuracy and performance in mathematics with a sample of 90 fifth-grade students. Analyses were conducted for the complete sample as well as a sample of at-risk group of low performing students who overestimated their skills. Results revealed that students who received feedback were more accurate in their self-evaluative judgments than students who did not receive feedback. For overconfident students, feedback additionally predicted calibration accuracy and performance.

1.3. Feedback, affect and self-regulated learning

In addition to the importance of feedback in relation to calibration and performance outcomes, affective outcomes are also associated with feedback and, according to Carver and Scheier (1990), affective reactions shape self-regulated learning. In their model of self-regulated learning, Carver and Scheier propose that affective reactions arise when a learner monitors progress toward a goal and compare the initial expected rate of progress to actual progress. When discrepancies between initial goals (e.g., initial expectations) and outcomes (actual progress) are minimal (e.g., progress is on target), then affect is neutral because expectations match actual progress. If a learner perceives progress on a task to be better than expected, or if feedback generated on products indicates performance is higher than anticipated, then affect is positive. If, however, expected progress or achievement is lower than expected, then this is accompanied by negative affect. Carver and Scheier further posit that these affective reactions may then help (when positive affect occurs) or hinder (when negative affect occurs) progress on a task. That is, affective products may influence subsequent engagement with the same or similar tasks by shaping judgments of confidence or helpfulness when learners monitor progress. However, when progress is judged to be less than optimal, this may trigger negative affect, which may lead a learner to disengage (an indicator of decreased motivation).

Empirical findings support the relationship between feedback and positive and negative emotions (Folkman & Lazarus, 1985; Pekrun, Cusack, Murayama, Elliot, & Thomas, 2014; Perry & VandeKamp, 2000; Turner & Schallert, 2001). For example, Perry and VandeKamp (2000) conducted classroom observations and retrospective interviews with young students (ages 5 through 9) to assess whether they could actually engage in self-regulatory behaviors, and evaluated whether students experienced negative affect after receiving negative feedback on writing products. They found that young students were in fact capable of regulating their learning with teacher support, and that 67% of students reported feeling sad when they made mistakes. What is not clear, however, is what effect this negative feedback had on students' subsequent learning. That is, despite the learning gains that studies have found with regard to feedback during learning with late elementary to adult samples (e.g., Labuhn et al., 2010; Saadawi et al., 2008), what is not clear is whether immediate feedback is effective for younger elementary students. In our review of the literature, although we found a number of studies that have explored the effects of immediate feedback on older elementary, high school, and university-level students, we found no studies that have explored the effects with early elementary students. Moreover, to our knowledge, researchers have not taken into consideration how immediate feedback may or may not affect learners' engagement experiences during learning.

Why is this important from a theoretical perspective? As noted above, most previous research on self-regulated learning has focused on students from upper elementary grades to university (c.f., Perry's work [Perry, 1998; Perry & VandeKamp, 2000]). The lack of previous research with younger elementary students reflected the long-held belief that young children were not capable of coordinating the cognitive and metacognitive processes needed to carry out complex tasks (Winne, 1997; Zimmerman, 1990). Although Perry's work reveals that young children are capable of regulating their learning, theorists have argued that there are developmental differences in students' ability to monitor their learning (Baker, 1984). Moreover, theorists have suggested that any feedback younger students receive will overwhelm cognitive resources, which would result in no increase in learning and possibly a disengagement from learning when feedback is negative. To date, this has not been empirically tested. As such, our primary research question was as follows: What is the effect of immediate feedback on kindergarten students' attitudes, emotions, engagement and learning outcomes in the context of literacy skills development?

2. The current study

After receiving feedback about the result of learning, individuals may engage in a comparison of how well they believe they are doing with how well they are actually performing. This comparison influences their self-judgments, which in turn trigger self-reactions. Given that the majority of learners tend to be overconfident (Pajares & Miller, 1997), we predicted that kindergarten students would also overestimate their performance on a series of literacy tasks. As such, we hypothesized the following: (1) If individuals experience negative evaluative feedback, this may negatively affect their self-evaluations; learners' dislike for a task may increase, their enjoyment may decrease, behavioral engagement may decrease (Zimmerman & Labuhn, 2012), and boredom may ensue (Pekrun, 2006) compared to when no feedback is provided. These negative emotional experiences may then have a negative effect on learning outcomes (e.g., Daniels, Stupnisky, Pekrun, Haynes, & Perry, 2009; Meece, Wigfield, & Eccles, 1990; Pekrun, Elliot, & Maier, 2009). Specifically, from the achievement emotions literature (e.g., Pekrun, 2006), when individuals are provided with unexpected feedback (e.g., that an answer is incorrect when they expected the answer to be correct), this can result in cognitive incongruity (Gaessler, Lu, Olde, Cooper-Pye, & Whitten, 2005; Vanlehn, Siler, Murray, Yanauchi, & Baggett, 2003). Individuals may then attempt to provide a correct answer again but, if the cognitive incongruity cannot be resolved (an individual continues to get the wrong answer), then frustration and eventually boredom may occur, which results in disengagement from the task and lower levels of achievement (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011).

However, younger elementary students may be able to interpret immediate feedback in ways that improve their learning. As such,
we hypothesized that: (2) learners may interpret immediate feedback in ways that prompt them to adjust their approaches to learning, which may then result in higher levels of achievement (Labuhn et al., 2010) compared to when no feedback is presented. Under this condition, if performance improves, then positive self-evaluations may result and learners’ attitudes, enjoyment and behavioral engagement may increase, whereas boredom may decrease (Pekrun, 2006). Moreover, because previous research has demonstrated gender differences in attitudes towards literacy tasks (Swalander & Taube, 2007), enjoyment (Villiger, Niggli, Wandelner, & Kutzelmann, 2012), and achievement for literacy tasks (Swalander & Taube, 2007; Viljaranta, Lerkkanen, Poikkeus, Aunola, & Nurmi, 2009; Villiger et al., 2012), we also hypothesized that: (4) girls would experience more positive attitudes and positive emotions, greater behavioral engagement, and lower levels of boredom compared to boys. We did not, however, expect an interaction between feedback condition and gender given the lack of evidence from previous research.

We tested these hypotheses over a series of two studies. For both studies, to provide a richer analysis of the data, we first interviewed a purposive sample of kindergarten students (five to six years of age) to explore their attitudes toward using various tablet apps for learning and, following Perry and Vandekamp (2000), to gauge their emotional reactions to receiving feedback when using the tablets. We then examined the effects of technology-mediated immediate feedback on students’ attitudes, emotions, behavioral engagement, and learning outcomes during the development of literacy skills (e.g., letter identification, phonemic awareness). Various tablet apps were used to provide dichotomous continuous feedback (correct or incorrect) over a series of tasks that ranged in level of difficulty (beginning easy, then progressively more difficult over the trials). Because of the small sample sizes in each study, we used a crossover repeated measures design. Students participated in both the feedback and no feedback sessions, in random order. In one session, students carried out various literacy tasks that provided no feedback. In the other session (one to two days later), students carried out similar literacy tasks that provided continual feedback (or vice versa). For Study 1, we tested one sample of students eight months into the school year. For Study 2, we tested a new sample of students seven weeks into the school year and again at eight months into the school year. All students across both studies had the same kindergarten teacher. Study 2 was conducted to replicate Study 1, but to also extend it to assess whether immediate feedback had similar effects early in the school year at an even younger age. That is, given that major cognitive developmental gains can occur between five to seven years of age (e.g., from pre-operational to cognitive operational [Demetriou, 1998]), we assessed whether patterns of results would replicate when students were younger (5-years-old) versus older (6-years-old) within the same sample over time during this critical developmental period.

3. Study 1 Methodology

3.1. Participants

Thirty-one kindergarten students (n = 16 girls) from two classrooms in one elementary school volunteered to participate (100% participation rate). Students were enrolled in an English school in the province of Quebec, Canada. As mandated by the province of Quebec, the English program is a bilingual program wherein students spend one day in French class followed by one day in English class, with Fridays split between the two. As such, the two classrooms have the same English teacher for English and same French teacher for French. Of the 32 students, 28 were first-language English and the other four were first language French but were fully bilingual in both languages (fathers were first-language English). Their average age was 73.64 months (SD = 3.21). Of the 31 students, 28 were Caucasian, and three were Indo-Canadain. Reflected in this group were three low-achieving, 17 average-achieving, and 11 high-achieving students. Additionally, the school was located in a sub-urban area that drew students from low income, low-middle income, middle income, high-middle income, and high income neighborhoods. All students had the same English kindergarten teacher. Of the 31 students, 16 were chosen purposively by the kindergarten teacher to participate in the interview (to ensure a representative sample of students from all ability levels). As reported by their parents, 12 reported having a tablet or similar device (e.g., iPod) at home (37.5%), 11 reported using it for games (34.4%) and 10 (33%) indicated that they use tablets at home for educational purposes.

3.2. Materials

3.2.1. Prior knowledge

To measure students’ prior knowledge of the literacy skills tested for this study, the kindergarten teacher individually tested all children in both classrooms to assess their literacy skills using provincially mandated materials from their regular curriculum. Assessment included letter identification, letter order, phonemic awareness with individual and blended letters, as well as basic sight words. She then rated each student along a four-point ability level scale ranging from 1 (low ability) to 4 (high ability), which is standard grading policy in the province of Quebec for kindergarten students. Reliability for the prior knowledge assessment was .92.

3.2.2. Interviews

Because iPads are used at the school in which the research was conducted, we assessed students’ attitudes toward using iPads in the classroom using a structured interview protocol (as opposed to asking them about tablets in general). Students were asked to:
(1) “Tell me some of the things you use an iPad for at school.”
(2) “Tell me what you like about the iPad.”
(3) “Tell me what you do not like about the iPad.”
(4) “Tell me what you have learned from using the iPad at school.” And, (5) “I have these activity sheets and this iPad. What would you prefer to use to learn the alphabet? The activity sheets or the iPad?”

3.2.3. Attitudes

A modified version of McKenna and Kear’s (1990) Elementary Attitude Scale was used to assess students’ attitudes toward the activities they just completed. Students responded to six items of three pairs each. The first item asked students if they liked a specific activity they just completed (e.g., “Did you like playing the Pocket Phonics game? Yes or No?”) and the second item asked students to report how much they liked or did not like that particular activity (e.g., “How much did you like it (or not like it)?”) on a four-point scale depicting the Garfield character as “Disliked it a lot” (a score of 1) to “Liked a lot” (a score of 4). The three Likert items were

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1 Rather than randomly assigning students to one of two conditions wherein the sample size per group would be 16 each, we used repeated measures to double the sample size per group and increase power to detect differences across conditions (see Shadish, Cook & Campbell, 2001).

2 The teacher was not a collaborator or author in this study, but tested them due to her expertise with assessing students’ prior knowledge in the content area chosen.
averaged to create a subscale score. Cronbach alpha reliability estimates for the feedback and no feedback condition were .70 and .71, respectively.

3.2.4. Emotions

To assess students’ levels of enjoyment and boredom during learning, we used six items from Pekrun et al.’s (2007) Achievement Emotions Questionnaire — Elementary Version. Students responded to three items that measured their enjoyment for the activities they just completed (e.g., “I enjoyed playing the Pocket Phonics game today”) and three items that measured their level of boredom (“The Pocket Phonics game was boring”) on a five-point gender-specific facial rating scale ranging from “not at all” (a score of 0) to “very much” (a score of 4) (a picture of a boy or a girl depicting each level of that particular emotion). Item order was randomized. Cronbach alpha reliabilities for enjoyment and boredom were .89 and .82, respectively, for the feedback condition, and .72 and .85, respectively, for the no feedback condition.

3.2.5. Engagement

We used Ozdemir’s (2011) 10-s momentary time sampling method to measure each student's behavioral engagement during task completion. One trained research assistant observed each student as the student completed all activities while the researcher conducted the session. On-task and off-task behaviors (both active and passive) were collected on an observation sheet for a particular moment every 10 s. Momentary time sampling required the trained observer to indicate whether the student was engaging in the defined on-off task behavior at each 10-s interval. Three categories were a priori defined: on-task; off-task, active; and off-task passive. On-task behavior was defined as the student attending to the assigned work. Examples of on-task behaviors included working on the assigned task, or asking the researcher relevant questions. Off-task, active behavior was defined as being actively disengaged from the required work. Examples included randomly selecting responses in rapid succession (i.e., gaming the system), searching the iPad for other games, or talking to the researcher about topics not related to the work. Off-task, passive behavior was defined as being disengaged during the activity, and included students laying their head on the table, or looking away from the task for a prolonged period of time (more than 7 s).

3.2.6. Literacy tasks

To assess students’ literacy achievement, a variety of tasks were assigned to students from basic letter identification to more advanced sight words. All activities were chosen in collaboration with the teacher to ensure the appropriateness of tasks. Literacy tasks included letter identification, letter order, letter sounds, consonant blends, and sight words. For example, for letter identification, students were shown letters and were asked to identify the letter. For letter order, students were asked to place the letters (randomly listed) in the correct order and, for another task, were asked to connect the dots in order from A to Z. For letter sounds (phonemic awareness), students heard the sound and were asked to identify which letter made that particular sound by selecting from different options, or were presented pictures of various objects (e.g., horse, present, apple) and were asked to identify the first letter of that particular word from a list of 3–5 different letter options. For consonant blends, students were presented pictures of different objects and were asked to identify which two letters began that particular word from a list of 3–5 different letter options. Finally, for sight words, students were presented 10 words and 10 objects that matched those words and were asked to place each object inside the matching word (e.g., fan, pig, pup, bug, bus, sun). Students could complete a total of 85 assigned tasks. For both conditions, the tasks were analogous. The only difference between the two conditions was the feedback that was or was not provided. Reliability for the feedback and no feedback conditions for the literacy tasks were .84 and .83, respectively.

3.3. Procedure

Informed consent forms, which described the purpose and specific procedures to be used in the study, were sent out to all children’s parents and 100% agreed to have their child participate in the study. In the last week of March (7th month of school), a purposive subsample of 16 kindergarten students participated in a structured interview to gain an understanding of their attitudes toward using tablets in the classroom (students had been using tablets in the classroom since the third week of school [September] of that school year). Each student was first asked for his or her assent to be interviewed individually in a resource room at the school. Each interview lasted approximately 10 min and was audio-recorded and then transcribed verbatim. During that same week, the kindergarten teacher individually tested all children to assess their literacy skills using provincially mandated materials from their regular curriculum.

The following week was in the first week of April, the full Study 1 sample of students (N = 31) participated in two sessions within one or two days apart. Each student provided his or her assent to participate (students were asked if they would like to play some games on the iPad with the researcher and her assistant). Each session was conducted individually in a resource room at the school. For each session, the researcher described the activities to the students, instructed them on how to proceed, recorded and scored students’ responses and, when students completed the tasks, read each item of the questionnaires to the students and recorded their answers. During the same session, the research assistant observed each student and recorded on-off task behaviors to measure student engagement. Because students varied in their level of literacy skills, and it was a repeated measures design (students participated in both conditions), each student was given 10 min for each session to complete as many tasks as possible (to ensure equivalent time across each condition), but were not informed of the time limit. Rather, they were told to complete the tasks at their own pace. Tasks began at an easy level to progressively more challenging to ensure students received a mix of positive and negative feedback. Moreover, there was a set number of tasks given to students for each literacy skill tested. Once students reached the set number, the researcher switched tasks.

Order of student participation was randomly selected (no differentiation was made as a function of classroom; all students were considered as one group). Students were then randomly assigned to the condition in which they would be tested first (feedback versus no feedback). In one session, students received technology-mediated immediate feedback in the form of the answer being correct or incorrect. Each tablet app provided a buzzing sound if students entered an incorrect answer, or cheering and clapping sounds if they entered a correct answer. When incorrect answers were provided, students had the opportunity to try again. For example, for one app, students were presented a letter, heard the sound the letter makes, and were asked to repeat the sound. After four letters were presented, the app sounded out one of the four letters and students were required to select from a list of letters the letter that made that particular sound. If students chose incorrectly, the incorrect option was removed and students could make another selection. All students, when incorrect, continued until they identified the correct answer (for all apps). More letters were then presented and the pattern repeated with more letters and more sounds. In the second session, students completed similar tasks but
were not provided any feedback as to whether their answers were correct or incorrect. After each session, the researcher read the self-report items\(^3\) to the students and then recorded students’ answers. Achievement for each session was then calculated as a function of number correct divided by number correct plus incorrect. Subsequent correct and incorrect answers that were provided after an initial incorrect answer were recorded but not included in the calculation to ensure an unbiased scoring procedure was used. Once students completed both sessions, they chose a gift to take with them as a thank you for their participation (e.g., little stuffed animal, toy car, etcetera).

3.4. Analytic design

To assess the effects of feedback on students’ attitudes, emotions, engagement, and learning outcomes, we used a repeated measures ANCOVA design. The independent variables included gender (boy versus girl) as the between subjects variable and learning condition (feedback versus no feedback) as the within subjects variable. The dependent variables included attitudes, enjoyment, boredom, engagement, and learning outcomes. The covariate for all analyses included students’ level of prior knowledge.

4. Study 1 results

4.1. Students’ attitudes toward using tablets in the classroom

Students’ (\(n = 16\)) responses to the five structured interview questions were transcribed verbatim and then analyzed by the first author and three trained graduate research assistants. We first jointly conducted a content analysis of students’ responses to identify themes and topics. Following identification of the themes and topics, we then quantified students’ responses by counting the frequency with which a particular answer was provided. The first author and all three graduate assistants coded all 16 students’ responses separately. Inter-rater agreement was established at 98%. Results from quantification of their responses revealed that students held very positive attitudes towards using tablets in the classroom for learning purposes. For example, when asked what they used tablets for in the classroom, students frequently mentioned specific games that they played, such as “Monster Ate My Homework,” and “Bugs and Buttons,” mentioned games in general, or specific apps for learning. These games were touted as “so much fun” and “really cool.”

Table 1 presents the results of the analysis for each question. We highlight a few key findings here. First, for using the tablet, the most frequent responses included specific games, games in general, and literacy apps. Two interesting responses we noted were that students used tablets to encourage people to learn, including seniors (the teacher paired kindergarten students with students from grade 5, and they visited seniors to teach them how to use tablets). For the second question, what they liked about using tablets, responses reflected a similar pattern to the first question. Students frequently reported that they really liked the games, and that using the apps were fun. Students also reported that they liked learning from using the tablet apps, like math and letters, and that they particularly enjoyed receiving the positive feedback. Finally, some students reported that they liked being challenged (e.g., “I like when there’s a hard level and I have to figure it out by myself”).

\(^3\) All items were pilot tested on a small sample of kindergarten students, and approved by the teacher, prior to using them for this study.

When asked what they did not like about it, 12 students said, “I like everything” or “Nothing. I like it all.” However, three students reported that they did not like being limited with the tablet, such as not being allowed to take it out of the classroom, did not like having to share it, or be disturbed by other students while using it. Two students also reported they did not like getting answers wrong. When asked what they have learned while using the tablet, 14 students reported they learned how to draw and identify their numbers, how to do math, how to draw and indentify their letters, and topics, we then quantified students’ responses by counting the frequency with which a particular answer was provided. The first author and all three graduate assistants coded all 16 students’ responses separately. Inter-rater agreement was established at 98%. Results from quantification of their responses revealed that students held very positive attitudes towards using tablets in the classroom for learning purposes. For example, when asked what they used tablets for in the classroom, students frequently mentioned specific games that they played, such as “Monster Ate My Homework,” and “Bugs and Buttons,” mentioned games in general, or specific apps for learning. These games were touted as “so much fun” and “really cool.”

Table 1 presents the results of the analysis for each question. We highlight a few key findings here. First, for using the tablet, the most frequent responses included specific games, games in general, and literacy apps. Two interesting responses we noted were that students used tablets to encourage people to learn, including seniors (the teacher paired kindergarten students with students from grade 5, and they visited seniors to teach them how to use tablets). For the second question, what they liked about using tablets, responses reflected a similar pattern to the first question. Students frequently reported that they really liked the games, and that using the apps were fun. Students also reported that they liked learning from using the tablet apps, like math and letters, and that they particularly enjoyed receiving the positive feedback. Finally, some students reported that they liked being challenged (e.g., “I like when there’s a hard level and I have to figure it out by myself”).

When asked what they did not like about it, 12 students said, “I like everything” or “Nothing. I like it all.” However, three students reported that they did not like being limited with the tablet, such as not being allowed to take it out of the classroom, did not like having to share it, or be disturbed by other students while using it. Two students also reported they did not like getting answers wrong. When asked what they have learned while using the tablet, 14 students reported they learned how to draw and identify their numbers, how to do math, how to draw and identify their letters, and how to use the tablet. Finally, given the choice between using the tablet versus using activity sheets to learn, 15 of 16 students reported they would prefer to use the tablet.

4.2. The effects of immediate feedback on students’ attitudes, emotions, engagement, and learning outcomes

Means and standard deviations for all variables are presented in Table 2 for the full Study 1 sample (\(N = 31\)). Correlations between all variables are presented in Table 3. First, we tested for order effects. No order effects were found for any of the outcome variables. Second, we tested for normality, outliers, and sphericity for all outcome variables. With the exception of boredom across both conditions (skewness was 3.9 for the feedback condition, and 3.7 for the no feedback condition), all assumptions were met. Because repeated measures ANCOVA is robust to slight violations of normality, we conducted this analysis for all outcomes.

To examine the effects of immediate feedback compared to no feedback on students’ attitudes towards learning, we conducted a repeated measures ANCOVA, with condition as the within subjects variable (feedback versus no feedback), gender as the between subjects variable, and prior knowledge as the covariate. Results revealed no significant differences. There was no main effect for condition, \(F(1, 28) = .10, p > .05\), no main effect for gender, \(F(1, 28) = .72, p > .05\), and no condition by gender interaction, \(F(1, 28) = 3.20, p > .05\).

For enjoyment, a repeated measures ANCOVA revealed a significant main effect for condition, \(F(1, 28) = 4.84, p = .036, \eta^2 = .14\), a main effect for gender, \(F(1, 28) = 6.32, p = .017, \eta^2 = .18\), but no interaction, \(F(1, 28) = 1.22, p > .05\). Specifically, students enjoyed the no feedback condition more, and girls enjoyed the activities more than boys. For boredom, results revealed no significant differences. There was no main effect for condition, \(F(1, 28) = 1.89, p > .05\), no main effect for gender, \(F(1, 28) = 2.44, p > .05\), and no condition by gender interaction, \(F(1, 28) = 21, p > .05\). For engagement, due to the low number of both active and passive off task behaviors, we merged the two categories into one prior to analysis. Results of the repeated measures ANCOVA revealed no significant differences for condition, \(F(1, 28) = .47, p > .05\), gender, \(F(1, 28) = 1.12, p > .05\), and no condition by gender interaction, \(F(1, 28) = .63, p > .05\). Finally, for learning outcomes, a repeated measures ANCOVA revealed a significant main effect for condition, \(F(1, 28) = 20.61, p < .001, \eta^2 = .42\), but no main effect for gender, \(F(1, 28) = 1.98, p > .05\), and no condition by gender interaction, \(F(1, 28) = 1.25, p > .05\). Specifically, students performed better in the feedback condition compared to the no feedback condition.

5. Brief discussion of study 1

The purpose of Study 1 was to gauge kindergarten students’ perceptions of using tablets in the classroom, and to assess the effect of immediate feedback on their attitudes, emotions, engagement, and achievement over a series of literacy tasks. Analysis of students’ interview responses showed an interesting pattern; students reported that they enjoyed using the tablet for learning purposes and especially enjoyed receiving positive
feedback when their answers were correct. However, students also noted that they did not like the negative feedback they received when their answers were incorrect. This pattern (like positive feedback, dislike negative feedback) may help to explain the lack of a difference between conditions for students' attitudes, boredom, and behavioral engagement during learning. That is, results revealed no differences in students' attitudes, boredom or engagement between the feedback and no feedback conditions. It may be the case that the positive feedback students received eliminated any negative effects that negative feedback may have had on these variables during learning with the tablet apps, even after controlling for students' prior knowledge.

It is also important to note that students performed generally well across the literacy tasks. Their overall average performance was in the high 70s, which suggests that students received more positive feedback than negative feedback. Despite receiving more positive feedback, results also revealed that students enjoyed the no feedback condition more and, consistent with previous research (Villiger et al., 2012), girls enjoyed the activities overall more than boys. As such, although feedback did not affect attitudes, boredom, or engagement, it did have a negative effect on students' levels of enjoyment. Interestingly, this lower level of enjoyment in the feedback condition did not result in a lower level of achievement. Rather, students' performance was higher in the feedback condition compared to when no feedback was given. We interpret this result to suggest that students, even as young as 5–6 years old, were able to interpret the negative feedback in a way that allowed them to make adjustments to their learning to improve learning outcomes. We find this particularly noteworthy and important from a theoretical perspective, given that researchers have previously assumed that children at this age do not have the skills necessary to regulate such feedback or cannot regulate feedback due to the overwhelming cognitive demands.

Table 1
Frequencies of categories of answers of kindergarten students in interview about tablets (Study 1).

<table>
<thead>
<tr>
<th>Categories</th>
<th>Frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>A specific game</td>
<td>23</td>
</tr>
<tr>
<td>Monster ate my homework</td>
<td>12</td>
</tr>
<tr>
<td>General game playing</td>
<td>17</td>
</tr>
<tr>
<td>Playing games</td>
<td>3</td>
</tr>
<tr>
<td>Learning letters with games</td>
<td>3</td>
</tr>
<tr>
<td>Letter School</td>
<td>15</td>
</tr>
<tr>
<td>ABC tracer/Tracing letters</td>
<td>7</td>
</tr>
<tr>
<td>Learning numbers</td>
<td>8</td>
</tr>
<tr>
<td>Tracing numbers</td>
<td>7</td>
</tr>
<tr>
<td>Learning to count</td>
<td>7</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
</tr>
<tr>
<td>&quot;To encourage people&quot;</td>
<td>7</td>
</tr>
<tr>
<td>Reading books</td>
<td>7</td>
</tr>
<tr>
<td>What do you like about it?</td>
<td>7</td>
</tr>
<tr>
<td>Playing games</td>
<td>16</td>
</tr>
<tr>
<td>It's fun</td>
<td>14</td>
</tr>
<tr>
<td>&quot;Makes me happy&quot;</td>
<td>8</td>
</tr>
<tr>
<td>Positive feedback</td>
<td>5</td>
</tr>
<tr>
<td>&quot;It's encouraging&quot;</td>
<td>5</td>
</tr>
<tr>
<td>Specific Games</td>
<td>5</td>
</tr>
<tr>
<td>Bugs and buttons</td>
<td>5</td>
</tr>
<tr>
<td>Making cupcakes</td>
<td>5</td>
</tr>
<tr>
<td>Learning</td>
<td>7</td>
</tr>
<tr>
<td>&quot;You can learn everything&quot;</td>
<td>7</td>
</tr>
<tr>
<td>&quot;It helps getting math in your head&quot;</td>
<td>7</td>
</tr>
<tr>
<td>Modeling</td>
<td>2</td>
</tr>
<tr>
<td>&quot;The iPad shows you how to do it first&quot;</td>
<td>2</td>
</tr>
<tr>
<td>Novelty</td>
<td>2</td>
</tr>
<tr>
<td>&quot;I don't have one like that at home&quot;</td>
<td>2</td>
</tr>
<tr>
<td>It's interactive</td>
<td>2</td>
</tr>
<tr>
<td>It's challenging</td>
<td>1</td>
</tr>
<tr>
<td>It helps others</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2
Descriptive statistics of all variables (Study 1).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gender</th>
<th>N</th>
<th>Feedback condition Mean (SD)</th>
<th>No feedback condition Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude</td>
<td>Female</td>
<td>16</td>
<td>3.88 (.39)</td>
<td>3.88 (.29)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>15</td>
<td>3.53 (.74)</td>
<td>3.80 (.37)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>31</td>
<td>3.71 (.60)</td>
<td>3.84 (.33)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>α = .70</td>
<td>α = .71</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>Female</td>
<td>16</td>
<td>3.56 (.57)</td>
<td>3.75 (.32)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>15</td>
<td>2.63 (1.41)</td>
<td>3.20 (1.13)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>31</td>
<td>3.11 (1.15)</td>
<td>3.48 (.85)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>α = .89</td>
<td>α = .72</td>
</tr>
<tr>
<td>Boredom</td>
<td>Female</td>
<td>16</td>
<td>.03 (.13)</td>
<td>.16 (.63)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>15</td>
<td>.57 (.82)</td>
<td>.70 (1.26)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>31</td>
<td>.29 (.63)</td>
<td>.42 (1.01)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>α = .82</td>
<td>α = .85</td>
</tr>
<tr>
<td>Engagement</td>
<td>Female</td>
<td>16</td>
<td>97.11 (4.25)</td>
<td>99.02 (1.88)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>15</td>
<td>98.45 (2.29)</td>
<td>98.27 (2.69)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>31</td>
<td>97.76 (3.46)</td>
<td>98.66 (2.30)</td>
</tr>
<tr>
<td>Achievement</td>
<td>Female</td>
<td>16</td>
<td>85.47 (12.97)</td>
<td>78.49 (20.30)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>15</td>
<td>80.85 (12.45)</td>
<td>71.67 (23.49)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>31</td>
<td>83.23 (12.73)</td>
<td>75.19 (21.81)</td>
</tr>
</tbody>
</table>
Given the large developmental gains common among this age group, and since students at this school begin to use the tablets as early as the second week of school, we deemed it necessary to replicate these results, but to also assess whether students were able to integrate feedback in a meaningful way at an earlier point in the school year. As such, we replicated the above design with slight modifications with a new cohort of kindergarten students. To assess the effects of immediate feedback on this new sample, we tested them at the beginning of the school year and again towards the end of the school year. We detail Study 2 next.

6. Study 2 Methodology

6.1. Participants

Thirty-three kindergarten students (n = 16 girls) from two classrooms from the same elementary school as Study 1 volunteered to participate (100% participation rate). As in Study 1, both classrooms had the same English kindergarten teacher, which was the same teacher as Study 1. Students’ average age in October was 66 months (SD = 3.25). Of the 33 students, 31 were Caucasian and two were Indo-Canadian. Two were considered low achieving, 17 were average achieving, and 14 were high achieving. Like Study 1, students came from an eclectic mix of socio-economic status. Like Study 1, 16 were chosen purposively by the same kindergarten teacher as Study 1 to participate in the interview. As reported by their parents, 17 reported having a tablet or similar device at home (51.5%), all of whom reported using it for games and 11 (33.3%) indicated that they used them at home for educational purposes. For the testing conducted in April, 30 students participated (two were away sick for the week and one moved to another province).

6.2. Materials

6.2.1. Prior knowledge

To measure students’ prior knowledge for the literacy skills tested for this study, the teacher tested each student individually by asking them to name each letter of the alphabet. This basic assessment was used given that students had just started the school year and many were still learning to identify the letters of the alphabet. As such, the same prior knowledge test materials from Study 1 could not be used. She noted the total number of letters correctly identified, and then rated each student accordingly. Like Study 1, students were rated on a four-point ability level scale ranging from 1 (low ability) to 4 (high ability).

6.2.2. Interviews

To assess students’ attitudes toward using tablets in the classroom, we used the same structured interview and protocol that was used in Study 1.

6.2.3. Attitudes, emotions, and engagement

The same materials were used in October and again in April as reported in Study 1, but slightly modified for materials used in October to reflect the activities carried out. See Tables 5 and 7 for reliability estimates across conditions.

6.2.4. Literacy tasks

For October, two types of tasks were assigned to students including letter identification and letter order. All activities were chosen in collaboration with the teacher. Students could complete a total of 72 tasks. For testing in April, the same materials from Study 1 were used. Reliability estimates for the feedback and no feedback conditions were .87 and .85, respectively.

6.3. Procedure

Like Study 1, parental consent and student assent was first obtained (100% agreed to participate). In the second week of October (2nd month of school), a purposive sample of 16 kindergarten students participated in a structured interview to gain an understanding of their attitudes towards using tablets in the classroom (students had been using tablets in the classroom for three weeks). The same procedure as described in Study 1 was used. A second interview was not conducted in April. After interviews were completed, all students participated in two sessions (in random order, randomly selected) one to two days apart. Students were tested again in April of the same academic year using the same materials and procedure as noted in Study 1 (more advanced literacy tasks compared to those carried out in October). Like Study 1, for the feedback condition, if an incorrect response was provided, students had the opportunity to continue to provide answers until the correct answer was chosen (feedback continued for all responses provided). All students continued to provide responses until a correct answer was chosen. Subsequent correct and incorrect answers that were provided after an initial incorrect answer were recorded but not included in the calculation to ensure an unbiased scoring procedure was used.

7. Study 2 Results

7.1. Students’ attitudes towards using tablets in the classroom

Students’ responses to the five structured questions were transcribed verbatim and then analyzed by the first author and the same three trained graduate research assistants from Study 1. We first conducted a content analysis of students’ responses to identify themes and topics. Following identification of the themes and topics, we then quantified students’ responses by counting the frequency with which a particular answer was provided. Inter-rater agreement was established at 96%.
Table 4 presents the results of the analysis for each question. We highlight a few key findings here. First, for using the tablet, like Study 1, the most frequent responses included specific games, games in general, and literacy apps. For the second question, what they liked about using tablets, responses were similar to those in Study 1. Fourteen students said that they generally held positive attitudes toward using the tablet in the classroom for learning purposes. As such, based on students’ responses to the interview, we inferred that students generally held positive attitudes toward using the tablet in the classroom for learning purposes.

Means, standard deviations, and reliability coefficients for all variables are presented in Table 5 for October (N = 33). Correlations between all variables for both October and April are presented in Table 6, and descriptive statistics for April (N = 30) are displayed in Table 7. First, we tested for order effects. No order effects were found for any of the outcome variables for October or April. We then tested for normality, outliers, and sphericity for all outcome variables for data collected in October and April. With the exception of enjoyment for April in the no feedback condition (skewness = –4.1), all assumptions were met. As such, repeated measures ANCOVAs were conducted for all analyses.

To examine the effects of immediate feedback compared to no feedback on students’ attitudes, emotions, engagement, and learning outcomes, we conducted a repeated measures ANCOVA, with condition as the within subjects variable (feedback versus no feedback), gender as the between subjects variable, and ability level as the covariate. For October and April, results revealed no significant differences. There was no main effect for gender, F(1, 30) = 1.15, p > .05 (April), F(1, 27) = 2.29, p > .05 (April), no main effect for gender, F(1, 30) = 1.15, p > .05 (October), F(1, 27) = 2.29, p > .05 (April), and no condition by gender interaction, F(1, 30) = .01, p > .05 (October), F(1, 27) = .19 p > .05 (April).
For enjoyment, results from the repeated measures ANCOVA revealed no significant differences for both October and April. Specifically, there was no main effect for condition, $F(1, 30) = 1.11$, $p = .24$ (October), $F(1, 27) = .01$, $p = .92$ (April), no main effect for gender, $F(1, 30) = .36$, $p = .55$ (October), $F(1, 27) = .02$, $p = .91$ (April), and no condition by gender interaction, $F(1, 30) = .07$, $p = .79$ (October), $F(1, 27) = .01$, $p = .90$ (April). In contrast, for boredom, results for October revealed a significant main effect of condition, $F(1, 30) = 6.80$, $p = .01$, $\eta^2 = .19$, but no significant gender by condition interaction, $F(1, 30) = .12$, $p = .71$, $\eta^2 = .00$, and no main effect for gender, $F(1, 30) = 1.56$, $p = .22$. Specifically, students were more bored in the feedback condition compared to the no feedback condition. For April, however, there were no significant differences between conditions, $F(1, 27) = 1.01$, $p = .32$; no gender differences, $F(1, 27) = 1.48$, $p = .22$; and no interaction, $F(1, 27) = .24$, $p = .63$.

Analyses of students’ levels of engagement for October revealed a main effect for condition, $F(1, 30) = 12.25$, $p = .001$, $\eta^2 = .29$, but no main effect for gender, $F(1, 30) = .61$, $p = .43$; and no gender by condition interaction, $F(1, 30) = .01$, $p = .90$. Specifically, students engaged in more off-task behaviors when provided feedback than when no feedback was given. For April, there were no differences for condition, $F(1, 27) = .48$, $p = .50$; no gender differences, $F(1, 27) = .68$, $p = .43$; and no interaction, $F(1, 27) = 2.38$, $p = .13$.

Finally, for achievement, October results revealed no main effect for condition, $F(1, 30) = .58$, $p = .45$, no main effect for gender, $F(1, 30) = .68$, $p = .42$; and no condition by gender interaction, $F(1, 30) = .02$, $p = .91$. However, for April, like Study 1, results revealed a significant main effect for condition, $F(1, 27) = 10.85$, $p = .002$, $\eta^2 = .29$, but no significant main effect for gender, $F(1, 27) = .98$, $p = .33$, and no condition by gender interaction, $F(1, 27) = 1.31$, $p = .26$. Specifically, like Study 1, students performed better when provided feedback compared to when no feedback was given. We discuss these results next.

8. Brief discussion of study 2

The purpose of Study 2 was to replicate Study 1, and to assess whether the same pattern of results emerged early in the school year. Analysis of students’ interview responses at the beginning of the school year revealed that students held positive attitudes towards using tablets in the classroom. Because students had just begun using them in the classroom context, their responses were not as variable compared to the responses students provided in Study 1. However, similar to Study 1, students’ responses generally focused on the games they played when using the tablet. In contrast to Study 1, responses about what they did not like about it reflected issues with using it (too heavy, difficult to use), which is expected when individuals are learning how to use new technology.

Results from the quantitative analyses also revealed some interesting patterns of results. Given the different pattern of results between October and April, we discuss them separately. First, for October, like Study 1, feedback had no effect on students’ attitudes. However, unlike Study 1, feedback had no effect on students’ levels of enjoyment, but affected students’ levels of boredom and engagement wherein students’ boredom increased and engagement decreased when feedback was provided. Also in contrast to Study 1, feedback had no effect on students’ achievement, which suggests that students were not able to adjust their approaches to learning based on that feedback. To help interpret these results, we turn to students’ levels of prior knowledge and achievement. Clearly, students in this sample had a much lower level of prior knowledge at the beginning of the school year, which was also reflected in students’ levels of achievement. Average performance across tasks was just over 50% and, as such, in the feedback condition, students were receiving as much positive feedback as they were negative feedback. Surprisingly, this did not affect their levels of enjoyment, but it did have a negative impact on their levels of boredom and engagement.

Interestingly, the pattern of results for April replicated the results from Study 1, with the exception of the effect of feedback on enjoyment. Specifically, like Study 1, feedback had no effect on students’ attitudes, boredom, and engagement, but had a positive effect on their achievement. In contrast, feedback had no effect on students’ levels of enjoyment, and no gender effects were found. As such, like Study 1, by the 8th month into the school year, students were able to interpret the negative feedback in a way that allowed them to make adjustments to their learning to improve learning.
outcomes. Similar to Study 1, students’ performance by April on the same tasks as Study 1 was much higher (in the 70s), which suggests that by April, students received more positive feedback than negative feedback. As such, it may be the case that the ratio of positive to negative feedback is an important factor to consider. We broaden discussion of the theoretical and educational implications of these results next.

9. General discussion

The purpose of this set of studies was to develop a better understanding of kindergarten students’ perceptions of using tablets in the classroom, and to assess the effect of immediate feedback compared to no feedback on their attitudes, emotions, engagement, and achievement over a series of literacy tasks. In Study 1, students were assessed in their eighth month of school, whereas for Study 2, students were assessed in their second month and again in their eighth month of school. Results revealed that students espoused positive attitudes toward the use of tablets in the classroom for learning purposes, and that their attitudes did not change as a function receiving feedback during learning. This was one robust finding across both studies. Interestingly, the pattern of results was similar for testing done in April wherein for both studies, feedback had no effect on boredom or engagement, and had a positive effect on learning outcomes. In contrast, October results revealed that feedback increased boredom and decreased engagement, but had no effect on learning outcomes. We discuss these results in turn.

9.1. Attitudes

For our set of studies, we explored whether feedback influenced students’ attitudes toward learning for this set of literacy tasks. Recall that one key facet of self-regulated learning is feedback during learning (Carver & Scheier, 2000; Muis, 2007; Winne & Hadwin, 1998; Zimmerman, 2000). Feedback can provide valuable information with regard to how well one is carrying out a task, and whether to make adjustments to self-regulatory processes to ensure sufficient progress on that task (Zimmerman & Labuhn, 2012). This feedback may also drive changes to an individual’s self-perceptions about their ability, which can affect their attitudes toward that task (Bandura, 1986; Pekrun, 2006). Across both studies, students’ attitudes did not change as a function of receiving immediate performance feedback across a series of tasks. Rather, attitudes remained positive even when students received an equivalent proportion of positive to negative feedback (October, Study 2). As such, it may be the case that early elementary students’ attitudes are not particularly susceptible to change, at least with regard to any dissonance that may arise from negative feedback (Festinger, 1957). Perhaps to affect attitudes via feedback, far more negative feedback is necessary. It is also possible that preschool children are more susceptible to social desirability influences and thus were less likely to admit disliking the activity. Nevertheless, feedback did affect students’ emotions and engagement.

9.2. Emotions and engagement

Given that tasks progressively increased in level of difficulty, we expected that all students at some point would experience negative feedback. If individuals experience negative evaluative feedback, this may result in a decrease in enjoyment and an increase in boredom (Pekrun, 2006) compared to when no feedback is provided. When boredom occurs, this results in a decrease in engagement (Pekrun, 2006). Results from our study were mixed. For Study 1, students’ enjoyment was lower in the feedback condition, but boredom was equal across conditions. For Study 2, students experienced more boredom in the feedback condition, but enjoyment was equivalent across the two conditions in October. By April, however, there were no differences in enjoyment or boredom. As previously discussed, the lack of a difference in April is likely a function of students’ relatively high level of performance. Both cohorts received positive feedback over 70 percent of the time. However, in October for Study 2, students received negative feedback half of the time. Under this condition, consistent with Pekrun’s (2006) control-value theory of emotions, students’ boredom increased, which also resulted in a decrease in engagement. Surprisingly, this did not result in a decrease in learning outcomes.

Clearly, the tasks that students completed in October for Study 2 were likely too challenging for many of the students, an explanation that is supported by flow theory and the Yerkes-Dobson law. According to flow, boredom will ensue when the challenge of the task is less than the individual’s competence level, whereas anxiety will arise when the challenge is too great (Csikszentmihalyi, 1975). Similarly, in accordance with Yerkes-Dobson law (Yerkes & Dodson, 1908), when one’s level of arousal is too low, such as when a task is perceived as too easy, boredom is more likely to be experienced, or when the task is perceived as too difficult, anxiety will be experienced, and consequently performance will be compromised. As such, future research, and teachers, should ensure that the specific learning tasks that students are engaging in are at the optimal difficulty level.

9.3. Achievement

Results from our set of studies revealed that, by April, students were able to effectively interpret feedback to make adjustments to their approaches to learning, which increased learning outcomes. Why might this be the case? Recall that immediate feedback from an external source, like computer-generated feedback, provides learners with information about how well they are performing (Butler & Winne, 1995) and may prompt learners to assess their progress on a learning task. Although this type of feedback does not inform students how to self-regulated their learning, it can initiate self-regulatory processes (Labuhn et al., 2010). When this occurs, students may become aware that they are not progressing as expected and may then adjust learning accordingly (Butler & Winne, 1995). Through continual and immediate feedback, students in our study were able to make adjustments to their learning to improve learning outcomes.

Despite this gain in April, an increase in learning outcomes did not occur when students were tested in October. There are several plausible explanations for these results. First, it could be the case that students were too young and did not have the cognitive capacity, skills, or resources to interpret the feedback in ways to adjust their approaches to learning (Butler & Winne, 1995). Second, it may be the case that the tasks were too difficult for students, and any adjustments made did not result in an increase in learning outcomes. Third, it is possible that students did not have the prior knowledge necessary for learning gains to occur even when provided with feedback. For example, Alexander, Murphy, Woods, Duohon, and Parker (1997) found that prior knowledge influences the types of strategies individuals use and the extent to which they use them. In their study, they found that learners with little to no prior knowledge were more likely to employ shallow processing strategies as opposed to deeper processing strategies, and were less likely to regulate their learning compared to students with more prior knowledge. Perhaps for our sample, given the lack of prior knowledge, students were not able to switch strategies given their lack of knowledge. However, by the eighth month of the academic year, students’ prior knowledge base was much richer, which may
10. Educational implications, limitations, and future directions

These results also have important educational implications. First, tablet applications that provide feedback to students as they complete several tasks can be beneficial for increasing learning outcomes. However, it is important that teachers select applications for students that are appropriate for their ability level—one that is neither too difficult nor too easy to ensure students remain engaged (e.g., Csikszentmihalyi, 1975; Vygotsky, 1978; Yerkes & Dodson, 1908). This task is made more challenging because students’ literacy abilities vary considerably across one school year, as demonstrated in the current study. However, the benefit of having a variety of applications available allows teachers the range of choice necessary to ensure all students have opportunities to improve their learning. In our study, we selected tasks that were at their appropriate level near the end of the school year, but were perhaps too challenging at the beginning of the school year. Future research should assess whether easier tasks at the beginning of the school year, coupled with feedback, enhance learning outcomes.

Once tasks are selected, the use of technologically-mediated feedback for literacy learning can dramatically change classroom instruction. Thirty students in a typical kindergarten classroom can receive individualized and immediate feedback on their performance simultaneously, freeing up a teacher to focus his/her attention on other instructional activities. However, such substantial changes raise other questions about their use beyond one session to their impact over time. For example, because this is their first formal educational experience, kindergarten students likely possess relatively unformed internal standards for learning and self-monitoring processes. Technologically-mediated feedback presents external standards and prompts monitoring. Therefore, key issues will be how applications and/or classroom instruction can move away from traditional feedback structures (positive vs. negative), fade scaffolding, and promote the internalization of standards and monitoring processes.

Another issue will be how to encourage students to continually return to and use beneficial applications over the long-term. As observed in the current study, achievement was promoted with the use of technologically-mediated feedback, but greater boredom and lesser enjoyment were likewise observed at different times. Thus, questions remain around how early literacy applications can be judiciously employed by teachers to ensure that student motivation is protected and promoted. Educational researchers can collaborate with teachers to share their findings with technology developers to address some of these issues to obtain long-term emotional, motivational, attitudinal, and educational benefits of technology for literacy acquisition.

11. Conclusion

In conclusion, we find the results of our work very promising. Like Perry’s work (Perry, 1998; Perry & VandeKamp, 2000), we found that children were indeed able to regulate their learning later in the school year to appropriately respond to feedback to increase learning outcomes. Theoretically, this has important implications with regard to evidence that young children are capable of regulating their learning and that cognitive demands were not too high given the increase in achievement in the feedback conditions. From a practical perspective, these results are important to share with teachers, particularly those who bring technology into their classrooms. Of course, much more work is necessary and much larger samples of students are needed to ensure sufficient power to detect differences across conditions. Future research is also needed that manipulates not only the feedback provided but also the level of difficulty of the tasks. This will allow researchers to assess whether interactions occur between level of difficulty and feedback. It may be the case that feedback is more or less effective with easier versus more difficult tasks.

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