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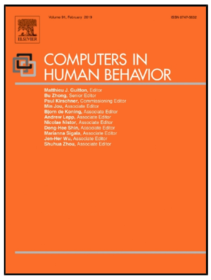

Exploring factors influencing the acceptance of visual programming environment among boys and girls in primary schools

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Exploring factors influencing the acceptance of visual programming environment among boys and girls in primary schools

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Abstract

There has recently been a renewed interest in integrating programming into the curriculum of primary education, partly due to the availability of the visual programming environment (VPE) designed for educational purposes. While substantial progress on exploring the potential benefits of VPE has been achieved, much remains to be done to understand students' acceptance of VPE and whether gender difference plays a role in their acceptance. This study was thus designed to extend the technology acceptance model to identify determinants influencing boys' and girls' behavioural intention to use VPE in the primary school context. It used a mixed method approach to evaluate the proposed model using questionnaire and interview data collected from 431 students (296 boys and 135 girls) in 38 primary schools. Among boys and girls, computer self-efficacy is shown to be the external factor significantly influencing both perceived usefulness and perceived ease of use of VPE, while attitude towards VPE is found to have a significant effect on behavioural intention to use VPE. In addition, gender differences are found in the impact of social influence and external encouragement on students' perceptions towards VPE, and also in the impact of students' perceptions towards VPE on their behavioural intention to use it. Based on the findings, several recommendations are made to encourage primary students to use VPE for programming.

Exploring factors influencing the acceptance of visual programming environment among boys and girls in primary schools

1. Introduction

Programming has been around in education for half a century. It can be viewed as a process of creating a sequence of computer instructions using a specific programming language to perform certain tasks (Fessakis, Gouli, & Mavroudi, 2013). Some previous studies found that programming could develop students' creativity (Pardamean & Evelin, 2014; Resnick et al., 2009) and problem-solving skills (Akcaoglu, 2014; Feurzeig & Papert, 2011). However, some other studies argued that it was very difficult to grasp the knowledge and skills to develop a computer program (Govender, 2009; Yang, Hwang, Yang, & Hwang, 2015).

Young students had very limited experience of learning computer programming in schools because programming was not a core part of the formal curriculum for decades (Bers, Flannery, Kazakoff, & Sullivan, 2014). In recent years, however, there has been a growing and widespread interest in equipping primary students with the knowledge and skills required for programming. Much of this interest stems from three recent developments. The first one concerns a rise in the educational visual programming environment (VPE) such as Scratch (Lee, 2010; Resnick et al., 2009), Kodu (Akcaoglu, 2014) and App Inventor (Hsu, Rice, & Dawley, 2012). The second refers to an increase in investment in science, technology, engineering and mathematics (STEM) education (Saxton et al., 2014), and the third to a growing awareness about the importance of computational thinking (Resnick et al., 2009).

Although previous research has highlighted the potential benefits of VPE for children, there has been scant research into factors influencing the acceptance of visual programming environment among boys and girls in primary schools, especially in the Asia-Pacific region. To bridge this research gap, the study was designed to explore primary students' acceptance of VPE in Hong Kong using a mixed method approach. The findings from this study can contribute to the literature by producing empirical evidence on the determinants of primary students' acceptance of VPE. They can also offer insights into areas where efforts can be concentrated to facilitate boys' and girls' use of VPE at the primary school level.

The rest of the paper is organised as follows. Section 2 presents a review of the literature relevant to this study. Section 3 proposes and describes the research model and hypotheses. Section 4 outlines the research methodology used in this study. Section 5 reports and discusses the results of this study. Conclusions and recommendations of this study are given in Section 6.

2. Related literature

2.1. The potential and challenge of learning programming

Back in the late 1960's, Logo programming language was invented as a tool to teach computer programming. It was specifically designed to engage children in the process of problem solving (i.e. decomposing a problem into sub-problems, planning and executing a solution, identifying errors and debugging) (Papert, 1983). Children could write Logo instructions to control the movement of a virtual turtle in order to create a drawing on screen. They could also view the actual drawing on screen to evaluate whether it was the same as the expected one. If something unexpected was found on screen, children could revisit their Logo instructions to identify problems and make revisions accordingly. Given these features, it was argued that programming has a great potential to foster students' creativity and problem-solving skills (Feurzeig & Papert, 2011; Papert, 1993).

The impact of programming on creativity was examined and discussed in the literature. Previous research suggested that programming could promote creativity in several domains. For example, early research investigated the effects of Logo programming on children's creativity and found that children in the Logo programming group could significantly outperform their counterparts in terms of figural and verbal creativity (Clement, 1991). A more recent study (Pardamean & Evelin, 2014) has likewise shown that Logo programming could lead to improvement in children's creativity, particularly in the areas of flexibility (i.e. the ability to try different approaches to a problem) and originality (i.e. the ability to produce unusual or smart ideas about a given topic or situation).

In contrast, the research findings about the impact of programming on problem-solving skills were less than conclusive. This was likely due to differences in the learning approach and the amount of time spent on learning activities. Kalelioglu and Gulbahar (2014) provided a group of primary students with the opportunity to work on several programming activities over five weeks, with one hour a week. They found that there was no significant difference in students' problem-solving skills before and after the experimental process, and they attributed this to the programming activities requiring lower-order thinking skills. In a study conducted by Akcaoglu and Koehler (2014), students joined an after-school training programme which consisted of five 3-hour sessions. In the training programme, they were engaged with the process of game design and programming to solve problems. It was found that the students showed a significant improvement in problem-solving and reasoning skills after the programme.

In addition, previous research also reviewed challenges to success of learning programming (Robins, Rountree, & Rountree, 2003). One major challenge facing novices was that they knew the syntax and semantics of each single statement in a programming language, but they did not understand how to combine the statements to create a valid computer program. Another major challenge was the difficulty of translating a known solution into an equivalent computer program for problem solving.

2.2. Gender and computer programming

Previous research found that female students generally lack confidence in their ability to learn computer programming, which resulted in a shortage of women majoring in computer science (Alvarado, Dodds, & Libeskind-Hadas, 2012; Carter & Jenkins, 1999). Over the years there have been efforts to explore gender differences in various aspects of programming, mostly in higher education. Some recent studies have investigated whether there could be gender differences in students' attitude towards programming (Baser, 2013; Korkmaz & Altun, 2013; Özyurt & Özyurt, 2015) and programming achievement (Lau & Yuen, 2009; Sullivan & Bers, 2016). However, the results are inconclusive and cannot be generalised to all student populations.

Some studies reported that there was no gender difference in programming achievement among students. For example, in a sample of 217 Hong Kong secondary students, Lau and Yuen (2009) found that females tended to perform better than males in a programming performance test. They attributed the differences in programming performance to learning ability rather than to gender. Similarly in a study of 45 kindergarten children in the United States, Sullivan and Bers (2016) found that boys and girls performed equally well in simple programming tasks, indicating that boys and girls possessed the same ability to acquire fundamental concepts of programming.

Baser (2013) involved 179 sophomores from an introductory programming course at a Turkey university to examine the relationships among gender, attitude towards programming and programming achievement. It was found that male students were more positive towards programming than female students because of males being more confident in their ability to learn programming, a finding aligned with other empirical research on the same issue (Korkmaz & Altun, 2013; Özyurt & Özyurt, 2015). It was also found that there was a positive correlation between students' attitude towards programming and their programming achievement. The findings suggested a reason why females tend to perform worse than males in programming.

In agreement with the findings of Baser (2013), Rubio et al. (2015) found gender differences in students' perceived ease of programming and behavioural intention to participate in programming. They argued and showed that the gender differences could be significantly reduced by using the physical computing approach (i.e. learn programming using physical objects such as robots and microcontrollers) rather than the traditional learning approach (i.e. learn programming from teaching slides and multimedia resources). While research has been undertaken into the relationship between gender and acceptance of the physical computing approach at the university level (e.g. McGill, 2012; Rubio et al., 2015), very little is known about gender and acceptance of VPE at the primary school level.

2.3. VPE and computational thinking

Given its potential to promote creativity and problem-solving skills, programming education began to receive attention in the research community in the 1980s. However, programming education was not widely made available to primary students at that time. Three recent developments have stimulated a renewed interest in integrating computer programming into the primary school curriculum. The first one refers to the availability of free VPE. VPE has not been formally defined in the literature, but it has often been referred to as a software environment enabling users to drag and drop blocks of code in a visual way. VPE can allow users to select appropriate blocks of code and snap them together to create complete programs. It can also offer visual clues to help users understand how to use the blocks, which can help lower the barrier to programming (Lye & Koh, 2014). Typical examples of VPE include Scratch (Lee, 2010; Resnick et al., 2009), Kodu (Akcaoglu, 2014) and App Inventor (Hsu, Rice, & Dawley, 2012).

The second pertains to a wave of enthusiasm for STEM education. STEM education was described as engaging students in inquiry-based learning to solve real-world problems and pursue innovation (Daugherty, 2013). Over the last decade, STEM education has increasingly become a key initiative to equip students with the ability to meet the future needs of the ever changing society (Saxton et al., 2014). Research has indicated that it would be helpful if students could be exposed to STEM education at an early age (Kazakoff, Sullivan, & Bers, 2013). To achieve the goal of promoting STEM education for children, it has been suggested that computer programming should be embedded in the primary school curriculum (Education Bureau, 2016; Smith, Sutcliffe, & Sandvik, 2014).

The third concerns an increased awareness about the importance of computational thinking in the digital era. Wing (2006) coined the term 'computational thinking' by characterising it as a way of "solving problems, designing systems, and understanding human behaviour, by drawing on the concepts fundamental to computer science" (p. 33). She added that this emerging form of thinking "represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use" (Wing, 2006, p. 33). Aho (2012) considered computational thinking as "the thought processes involved in formulating problems so their solutions can be represented as computational steps and algorithms" (p. 832). Given these features, it was argued that computational thinking conceptually intersects with 21st century skills such as creativity, critical thinking and problem solving (Lye & Koh, 2014). From a practice perspective, Lee et al. (2011) proposed that modelling and simulation, robotics, game development, webpage construction, mobile apps programming are some possible domains in which youngsters can develop their computational thinking skills. In these domains, programming is a key element to connecting and implementing ideas of computational thinking. Resnick et al. (2009) echoed this view and noted that programming activities can provide students with ample opportunities to practise computational thinking skills.

Previous literature reviews on computational thinking education in the K-12 context (Grover & Pea, 2013; Lye & Koh, 2014) have identified that a substantial body of research (e.g. Fessakis et al., 2013; Kazakoff & Bers, 2012) focused on examining the impact of interventions on students' understanding of programming knowledge (e.g. repetition, sequencing and conditional logic) and on their approach to programming (e.g. an iterative and incremental refinement approach to problem solving and analysis). However, much remains to be done, particularly in exploring the factors that influence the success of programming initiatives for children and determining whether there are gender differences in those factors.

2.4. Technology acceptance model

The technology acceptance model (TAM) (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989) has its roots in the theory of reasoned action (Fishbein & Ajzen, 1975). It is considered one of the most widely used models to predict users' acceptance of technology. According to TAM, there are two key factors of technology acceptance and usage. The first one, namely perceived usefulness, is defined as "the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context" (Davis et al., 1989, p. 985). The second, namely perceived ease of use, is referred to as "the degree to which the prospective user expects the target system to be free of effort" (Davis et al., 1989, p. 985). TAM posits that the two beliefs are determinants of users' attitudes towards the adoption of a new technology, which can in turn influence their behavioural intention to use the technology.

One limitation of TAM lies in its exclusive focus on perceived usefulness and perceived ease of use without explaining how the two beliefs are formed (Mathieson, 1991). To address this concern, Venkatesh and Davis (2000) extended TAM by adding external variables to explain perceived usefulness. These external variables include subjective norm, image, job relevance, output quality and result demonstrability. Venkatesh (2000) likewise proposed that perceived ease of use can be affected by a set of external variables including computer self-efficacy, facilitating conditions, computer playfulness and computer anxiety. A meta-analysis study of TAM reported that over 70 external variables were proposed by various researchers to account for different context-specific features of technology adoption, but most of them were designed for adults in the workplace (Yousafzai, Foxall, & Pallister, 2007). The study also classified the external variables into four different types: organisational characteristics (e.g. organisational support), system characteristics (e.g. relevance with job), users' personal characteristics (e.g. computer self-efficacy), and others (e.g. social influence).

Although TAM was originally proposed to predict users' acceptance of technology in the workplace (Davis et al., 1989), it has been increasingly validated as a theoretical model to explore primary students' acceptance of educational technology in different countries. For example, Cheng et al. (2013) applied TAM to examine fourth-grade students' acceptance of using a digital game-based learning (DBGL) system for environmental education in Taiwan. Elyazgi et al. (2016) undertook a TAM-based study to investigate factors that influence e-book technology acceptance among school children in Malaysia. Joo et al. (2014) carried out a similar study on primary students' acceptance of digital textbooks in South Korea. Gu, Zhu and Guo (2013) adopted TAM to explore differences between teachers' and students' acceptance of information and communication technology (ICT) in primary schools in China.

Due to differences in technologies and questionnaire items used by different TAM-based studies, the empirical findings on students' acceptance of a new technology were less than consistent (Deng, Doll, Hendrickson, & Scazzero, 2005). It could be problematic to generalise the results of previous studies beyond their original purposes and contexts, so it is worth conducting a new research into an emerging area of interest. For this reason, this study was framed using TAM to investigate factors influencing the acceptance of VPE among boys and girls in primary schools.

3. Research model and hypotheses

Fig. 1 illustrates the research model of this study. This model, adapted from TAM (Davis et al., 1989), was proposed to investigate factors influencing primary students' behavioural intention to use VPE. The proposed model comprises four major TAM-based constructs including perceived usefulness, perceived ease of use, attitude and behavioural intention. Furthermore, the model takes into account four external variables, namely computer self-efficacy, social influence, external assistance and external encouragement. These external variables were chosen by two experts with substantial experience working in TAM and computer programming education. They were also identified from the literature as impacting on perceived usefulness and perceived ease of use of a new technological system in educational contexts (Hsiao, Huang, Chen, & Chiang, 2017; Joo et al., 2014; Meelissen & Drent, 2008; Yousafzai et al., 2007).

[Insert Fig. 1 here]

Fig. 1. The research model of this study

3.1. Computer self-efficacy

Self-efficacy is a key construct grounded in social cognitive theory, which refers to an individual's confidence in his or her ability to successfully perform a specific task (Bandura, 1977). In the information technology domain, computer self-efficacy was characterised as an individual's perception of his or her ability to use a computer system for task accomplishment (Compeau & Higgins, 1995; Marakas, Yi, & Johnson, 1998). It was also identified as an external variable affecting behavioural intention to use a system through its direct influence on perceived usefulness and perceived ease of use (Yousafzai et al., 2007). The higher the sense of computer self-efficacy, the greater the motivation and effort to use a computer system. This would in turn affect perceived usefulness and ease of use of the system (Yousafzai et al., 2007). The effects of computer self-efficacy was well documented in higher education. For example, previous research indicated that computer self-efficacy is a determinant of perceived ease of use of the web-based learning environment (Yi & Hwang, 2003), while some others indicated that computer self-efficacy can influence both perceived usefulness and ease of use of e-learning environments (Park, 2009; Scott & Walczak, 2009) and virtual worlds (Shen & Eder, 2009). However, there has been very limited research into this issue in the primary school context (Joo et al., 2014). To add to the literature, therefore, the following two hypotheses were tested in this study:

H1: Computer self-efficacy has a positive effect on perceived usefulness.
H2: Computer self-efficacy has a positive effect on perceived ease of use.

3.2. Social influence

Social influence is viewed as a predictor variable of technology acceptance. Venkatesh and Davis (2000) integrated the concept of social influence into TAM to include the influence of important others on one's perception of technology, based on the theory of reasoned action (Fishbein & Ajzen, 1975). They expressed social influence in term of subjective norm, commonly referred to as an individual's perceived social pressure to engage or not in a behaviour. If an individual thinks that important others believe he or she should use a new system, he or she would likely build a positive perception of the system through social influence processes. In this connection, it is important to consider social influence in the analysis of system adoption. Previous research found that social influence can have a significant impact on perceived usefulness (Venkatesh & Davis, 2000) or perceived ease of use (Malhotra & Galletta, 2005; Shen, Laffey, Lin, & Huang, 2006) and thus on behavioural intention, especially at the initial stage of system adoption. In a recent study examining the acceptance of a game-based educational system among primary students, Hsiao et al. (2017) have found that social influence can help increase students' intention to use the system. However, they have not investigated the impact of social influence on perceived usefulness and perceived ease of use. The following two hypotheses were therefore developed for further investigation in the primary school context:

H3: Social influence has a positive effect on perceived usefulness.
H4: Social influence has a positive effect on perceived ease of use.

3.3. External assistance

In contrast to self-efficacy, external assistance focuses on one's belief about whether he or she can get assistance from external sources to successfully perform a behaviour. Based on the attribution theory (Weiner, 1985), Thatcher et al. (2008) argued that people would find a computer system easy to use if they could attribute the success of its use more to their own ability rather than external assistance (e.g. human support). They also argued that people would perceive the usefulness of the system if external assistance (e.g. adequate training) could be provided. On the contrary, Venkatesh and Bala (2008) found that external assistance can significantly impact on perceived ease of use but not on perceived usefulness. External assistance has been shown as a significant determinant of students' perception of technology use in secondary schools and universities (e.g. Nikou & Economides, 2017; Teo, 2009; Terzis & Economides, 2011), but it has received scarce attention within the primary school context. To fill this gap, the following two hypotheses were formulated for testing in this study:

H5: External assistance has a positive effect on perceived usefulness.

H6: External assistance has a positive effect on perceived ease of use.

3.4. External encouragement

External encouragement (e.g. peer and teacher encouragement) is identified as an external variable influencing human attitude and behaviour, which is underpinned by self-efficacy theory and social cognitive theory (McFarland & Hamilton, 2006). In higher education, external encouragement was cited as a facilitating condition for technology acceptance because students would find a technology useful if they could receive encouragement and support from peers and teachers (Lai, Wang, & Lei, 2012). Martins and Kellermanns (2004) shared the same view that external encouragement is a motivating factor associated with perceived usefulness. They specifically investigated factors affecting students' acceptance of a web-based course management system and found that external encouragement can positively influence students' perceived usefulness of the system. There was also evidence of a strong connection between external encouragement and perceived ease of use in a similar setting (Williams & Williams, 2010). In the primary school context, however, research suggested that students tend to have positive views on the usefulness of computer technology but not on its ease of use when receiving parental or peer encouragement (Meelissen & Drent, 2008; Vekiri & Chronaki, 2008). Hence, the following two hypotheses were examined in this study:

H7: External encouragement has a positive effect on perceived usefulness.
H8: External encouragement has a positive effect on perceived ease of use.

3.5. Technology acceptance model

As discussed earlier in the literature review, TAM (Davis, 1989; Davis et al., 1989) advocates that: (1) perceived ease of use can predict perceived usefulness; (2) both perceived usefulness and perceived ease of use are determinants of attitude towards technology; and (3) behavioural intention to use technology can be influenced by perceived usefulness and attitude towards technology. These relationships have been validated by limited research conducted within the primary school context (Cheng et al., 2013; Gu et al., 2013). Additionally, other research in primary education has demonstrated that perceived ease of use can exert an influence on behavioural intention to use technology (Elyazgi et al., 2016; Joo et al., 2014). All these possible associations were transformed into the following hypotheses for further examination in this study:

H9: Perceived ease of use has a positive effect on perceived usefulness.
H10: Perceived usefulness has a positive effect on attitude towards VPE.
H11: Perceived ease of use has a positive effect on attitude towards VPE.
H12: Perceived usefulness has a positive effect on behavioural intention to use VPE.
H13: Perceived ease of use has a positive effect on behavioural intention to use VPE.
H14: Attitude towards VPE has a positive effect on behavioural intention to use VPE.

4. Research methodology

4.1. Study context

To add to the literature on students' acceptance of technology, this study was conducted in an understudied context between December 2015 and March 2016. An invitation to participate in the study was faxed to all Hong Kong primary schools almost three months before the start of the study. Thirty-eight primary schools replied to accept the invitation. The participants of this study comprised students in Primary 4, 5 and 6 from those participating schools. They were required to attend an on-site workshop on introduction to programming. The workshop was designed by members of academic staff at a Hong Kong university to equip primary students with core programming skills over four lessons, each lasting two hours. A web-based VPE, namely App Inventor (http://appinventor.mit.edu), was used as the programming tool in the workshop. The specific objectives of the workshop were to help participants: (1) familiarise themselves with the user interface of App Inventor in the first lesson; (2) understand the purpose and use of various programming blocks offered by App Inventor in the second lesson; and (3) design, develop and test functional mobile apps using App Inventor in the last two lessons. After considering suggestions from previous research (Bers et al., 2014; Kalelioglu, 2015), the workshop took a learning-by-doing approach to engage participants in the process of programming. Prior to the study, ethical approval was sought and obtained from the ethics committee of a Hong Kong university.

4.2. Participants

Four hundred and thirty-one Chinese primary students registered for the programming workshop. An online self-completion questionnaire in Chinese was distributed to collect data on demographics of the participants at the end of the workshop. Table 1 shows the demographic information of the participants. As shown in the table, the majority of participants were students in primary 5 (40% of the boys' sample and 35% of the girls' sample) and primary 6 (44% of the boys' sample and 45% of the girls' sample), followed by those in primary 4 (17% of the boys' sample and 20% of the girls' sample). The ages of participants ranged from 8 to 12 or above years. At the time of survey, most boys (87%) and girls (92%) reported that they took part in at least one extra-curricular activity. Around two-thirds of boys (62%) and girls (68%) responded that they spent 1 to 5 hours on programming activities in the last 4 weeks. A vast majority of boys (94%) and girls (91%) perceived that their level of academic competence was average or above average. An informed consent form was secured from all participants and their parents at the outset of the study.

[Insert Table 1 here]

4.3. Questionnaire of student acceptance of VPE

An online questionnaire in Chinese, namely questionnaire of student acceptance of VPE, was developed to measure the constructs proposed in the research model. The questionnaire items were adapted from existing scales relevant to this study (Davis, 1989; Martins & Kellermanns, 2004; Park, 2009; Thatcher et al., 2008; Venkatesh & Davis, 2000). To ensure the clarity and validity of the items, the questionnaire was reviewed independently by two researchers with expertise in computer programming education. It was also trialled in a pilot survey of 20 students from a Hong Kong primary school. The respondents were asked to comment on the content and wording of the items. Refinements were made based on analysis of the comments. At the end of the pilot, there was only one minor revision to the wording of some items (from 'expect' to 'think') and no items were removed from the questionnaire. Table 2 shows the final English version of the questionnaire with 21 items: 2 items on computer self-efficacy (CSE), 3 items on social influence (SI), 3 items on external assistance (EA), 3 items on external encouragement (EE), 3 items on perceived usefulness (PU), 3 items on perceived ease of use (PEOU), 2 items on attitude towards VPE (AT) and 2 items on behavioural intention to use VPE (BIU). A 5-point Likert response format was used for all items, with responses ranging from 1 (strongly disagree) to 5 (strongly agree).

[Insert Table 2 here]

The main body of the questionnaire comprises the 21 items listed in Table 2. Besides, the questionnaire contains a section to gather demographic data of participants such as age and gender.

4.4. Semi-structured interview

Post-workshop group interview sessions were held with 4 classes of students (26 boys and 12 girls in total) which were randomly selected from the participating schools. All interview sessions were conducted in Cantonese, each lasting approximately 30 minutes. The interview protocol consisted of three questions:

- What made you to try VPE?
- What are the benefits and problems of VPE?
- What will enable you continue to use VPE in future?

The interview protocol was designed to collect qualitative responses to questions that were not covered in the questionnaire. These responses could provide a better understanding of students' views on the benefits and problems of VPE. They could also shed light on the factors associated with their first attempt and future intention to use VPE. The qualitative results were used to triangulate the findings of the questionnaire survey, which would offer useful insights into the determinants of students' acceptance of VPE.

4.5. Procedure

During each session of the on-site training workshop, participants were first asked to pay attention to the instructor's demonstration of how to build a simple app using App Inventor (see Fig. 2). They could then follow the step-by-step instructions set out in an e-book to create apps on their own (see Fig. 3). They could also seek in-class assistance from the instructor to rectify their misunderstanding and consolidate their learning. As an example, Table 3 provides key information about a lesson such as intended learning outcomes and class activities.

[Insert Fig. 2 here]

Fig. 2. The instructor's demonstration of how to build an app

[Insert Fig. 3 here]
Fig. 3. Part of an e-book about programming

[Insert Table 3 here]

At the end of the last session, the online questionnaire of student acceptance of VPE was administered to all participants. Since some respondents were only aged 8 or 9 years, they might have difficulty in understanding the meaning of the questionnaire items. The instructor therefore explained each item at the beginning of the questionnaire survey to ensure that all items were clear to respondents. After the workshop, semi-structured group interviews were conducted with a sample of participants to collect further responses.

4.6. Data analysis

The research model illustrated in Fig. 1 was analysed using a second-generation multivariate data analysis method, namely partial least squares structural equation modelling (PLS-SEM) (Wold, 1985; Hair, Hult, Ringle, & Sarstedt, 2017). Unlike the covariance-based structural equation modelling approach (CB-SEM) used to test and confirm theories, PLS-SEM was designed to estimate path relationships in a complex model with the objective to predict key constructs and develop theories (Chin, 1998; Hair et al., 2017). PLS-SEM was adopted for data analysis in this study because: (1) PLS-SEM has flexible data and model requirements where it can handle data with non-normal distribution and different scale types; and (2) PLS-SEM can work well with a large number of constructs and indicators and also with a small data set. These characteristics are useful for analysing the data obtained from the questionnaire survey.

For qualitative analysis, the interview data were audio-recorded and subsequently transcribed verbatim using NVivo. Thematic analysis was carried out to process the transcribed data through summarising, coding, writing memos and identifying categories (Braun & Clarke, 2006). The transcribed data were initially coded using open coding to identify concepts. Similar concepts were grouped into conceptual categories. Categories appearing to cluster together were developed into a theme. Major themes emerged from the data were analysed in relation to the findings from the PLS-SEM analysis.

5. Results and discussion

5.1. Descriptive statistics

Tables 4 presents the descriptive statistics summarising student responses to the questionnaire items. The average ratings of boys were between 3.50 and 4.27 and those of girls were between 3.37 and 4.06. This represents that respondents generally agreed with all the item statements in the questionnaire.

Amongst the responses received, PU1 (4.26 by boys and 4.06 by girls), PU3 (4.27 by boys and 3.97 by girls) and AT1 (4.26 by boys and 3.89 by girls) were rated highest by both boys and girls. While boys gave the lowest ratings to EA2 (3.58), PEOU3 (3.54) and EA3 (3.50), girls gave the lowest ratings to EA3 (3.39), PEOU1 (3.38) and PU2 (3.37). The results indicate that boys and girls tended to agree more with the usefulness of VPE (PU1 and PU3) and less with the ease of use of

VPE (PEOU1 and PEOU3) and receiving external assistance in using VPE (EA2 and EA3). The results also indicate that girls were more pessimistic than boys about using VPE to improve their performance in computer programming (PU2).

[Insert Table 4 here]

5.2. Reliability and convergent validity

The measurement models for boys (see Table 5) and for girls (see Table 6) were evaluated in terms of internal consistency, indicator reliability and convergent validity (Hair et al., 2017). Both tables show that all values of factor loading and composite reliability are well above the threshold value (0.7), suggesting that there is a high internal reliability for each construct and all indicators should be retained (Chin, 1998). The tables also show that the values of average variance extracted (AVE) are higher than the threshold value (0.5), so convergent validity of the constructs is confirmed (Chin, 1998).

[Insert Table 5 here]

[Insert Table 6 here]

5.3. Discriminant validity

Using the criterion of Fornell and Larcker (1981), Tables 7 and 8 summarise the results of discriminant validity tests on the constructs of the measurement model for boys and for girls, respectively. It is found that the square root of the AVE of a construct (i.e. the diagonal value of a construct) is higher than the correlation between that construct and any other constructs in the model. The results confirm discriminant validity as each construct explains more of the variation in its measures than in other constructs.

[Insert Table 7 here]

[Insert Table 8 here]

5.4. Hypotheses testing

This section discusses the results of the structural model. It focuses on evaluating the relationship between two constructs and determining whether a construct has a significant effect on another. Tables 9 and 10 present the evaluation results for boys and for girls, whereas Fig. 4 illustrates the outputs of the research model after applying PLS-SEM.

[Insert Table 9 here]

[Insert Table 10 here]

[Insert Fig. 4 here]

Fig. 4. Path coefficients of the research model

To explore the impact of the four external variables on perceived usefulness and ease of use of VPE, hypotheses 1 to 8 were formulated and tested. As shown in Tables 9 and 10, computer self-efficacy is important in influencing boys' and girls' perceived usefulness (H1, $p < .01$) and perceived ease of use (H2, $p < .01$). It has the largest effect on perceived usefulness ($f^2 = .167$ for boys, $f^2 = .301$ for girls) and perceived ease of use ($f^2 = .164$ for boys, $f^2 = .274$ for girls) in comparison with the other three external variables. The effect sizes of computer self-efficacy on both perceptions are considered medium (Cohen, 1988). These findings are in line with previous research which has shown that primary students' beliefs about their ability to use a technology could positively and significantly predict their perceptions of its usefulness and ease of use (Joo et al., 2014).

External encouragement is found to have significant effects on boys' and girls' perceived ease of use of VPE (H8, $p < .05$). Primary students tended to be more positive towards the ease of use of VPE when they received more external encouragement to work with it. This finding not only echoes similar results from previous work in higher education (Williams & Williams, 2010) but also provides evidence of the importance of external encouragement to primary students. Besides, it is found from Tables 9 and 10 that external encouragement can positively influence perceived usefulness of VPE among girls (H7, $p < .01$) but not boys (H7, $p > .05$). The findings are not entirely consistent with the results of previous research which identified a positive relationship between external encouragement and perceived usefulness of technology with no gender differences observed (Vekiri & Chronaki, 2008). The results of this study suggest there are gender differences in the effect of external encouragement on perceived usefulness. This may be attributed to the fact that girls tend to be less confident in their own ability to use computer technology and thus they rely more on external encouragement (Meelissen & Drent, 2008).

The remaining two external variables, external assistance and social influence, are associated with only one of the two beliefs. As can be seen from Tables 9 and 10, external assistance has significant effects on boys' and girls' perceived ease of use of VPE (H6, $p < .01$) with medium effect sizes ($f^2 = .164$ for boys, $f^2 = .188$ for girls). The findings, together with the evidence gathered in the secondary and higher education context (Nikou & Economides, 2017; Teo, 2009), can validate the association between external assistance and perceived ease of use for different age groups. In contrast, social influence is found to have a significant impact on perceived usefulness of VPE among boys (H3, $p < .01$) but not girls (H3, $p > .05$). That means boys but not girls tend to find a technology useful if their referent others (e.g. parents) share the same view. The results can contribute to the literature about the effects of social influence on technology acceptance among boys and girls in the primary school context since scarce attention was given to this issue.

To investigate the relationships between the three internal variables, hypotheses 9 to 14 were designed and tested. The results show that five hypotheses are supported for boys while three for girls, indicating that: (1) perceived ease of use of VPE does not have significantly positive effects on perceived usefulness of VPE among boys and girls (H9, $p > .05$); (2) perceived usefulness and perceived ease of use of VPE have significantly positive effects on attitude towards VPE among boys and girls (H10 and H11, $p < .05$); (3) perceived usefulness and perceived ease of use of VPE have significantly positive effects on behavioural intention to use VPE among boys but not girls (H12 and H13, $p < .01$ for boys and $p > .05$ for girls); and (4) attitude towards VPE has significantly positive effects on behavioural intention to use VPE among boys and girls (H14, $p < .01$). Most findings are consistent with previous research on TAM for working adults (Davis et al., 1989) and on factors affecting behavioural intention to use technology in higher education (Chow et al., 2012; Yeou, 2016). One major difference is the impact of perceived ease of use on perceived usefulness. While perceived ease of use could be predictive of perceived usefulness in higher education (Chow et al., 2012; Yeou, 2016), the causal relationship between perceived ease of use and perceived usefulness is insignificant among primary students in this study. This is reflected in Table 4, which shows that primary students gave low ratings to perceived ease of use of VPE but much higher ratings to perceived usefulness of VPE .

Gender similarities are found in the factors influencing attitude towards VPE. As discussed earlier, perceived usefulness and perceived ease of use can significantly influence attitude towards VPE among boys and girls. The effect sizes of perceived usefulness on attitude towards VPE are considered large ($f^2 = .640$ for boys and $f^2 = .359$ for girls), and those of perceived ease of use on attitude towards VPE are small ($f^2 = .149$ for boys and $f^2 = .074$ for girls). The results indicate that both boys and girls who perceive the usefulness and ease of use of VPE are likely to be positive towards VPE. These findings corroborate those reported in previous research (Cheng et al., 2013). On the other hand, gender differences are found in the factors associated with behavioural intention to use VPE. Boys' behavioural intention to use VPE is influenced by their perceived usefulness of VPE, perceived ease of use of VPE and attitude towards VPE. However, girls' behavioural intention to use VPE is mainly affected by their attitude towards VPE. The findings are in contrast to those of previous studies that identified perceived usefulness (Cheng et al., 2013) and perceived ease of use (Joo et al., 2014) as determinants of behavioural intention to use technology among primary students. An explanation for the differences in findings may be that the previous studies did not take account of gender issues in data analysis.

R-squared (R^2) was used as a goodness-of-fit measure in the PLS-SEM analysis (Hulland, 1999). As evident in Fig. 4, the proposed model can satisfactorily explain the variance in behavioural intention to use VPE (75% for boys and 81% for girls), attitude towards VPE (69% for boys and 63% for girls), perceived usefulness of VPE (67% for boys and 77% for girls) and perceived ease of use of VPE (67% for boys and 78% for girls). The values of R^2 indicate a moderate model fit (Henseler, Ringle, & Sinkovics, 2009). Another goodness-of-fit measure, namely standardised root mean square residual (*SRMR*), was also calculated and found to confirm an acceptable model fit for both boys and girls ($SRMR < .05$) (Henseler, Hubona, & Ray, 2016).

5.5. Emerging themes from qualitative analysis

Interview scripts were analysed to produce emergent themes that would contribute to a better understanding of primary students' views on VPE. Specifically, three key themes emerge from the data analysis: (1) motivating factors for VPE adoption; (2) perceived benefits and problems of VPE; and (3) motivating factors for continued use of VPE in future.

5.5.1. Motivating factors for VPE adoption

At the beginning of each interview, interviewees were asked about what made them to try VPE. Three categories were identified from their responses, constituting the theme of 'motivating factors for VPE adoption'. Twenty-seven students (20 boys and 7 girls) answered that they tried VPE because of teacher encouragement (Category 1). Of the rest, eight (6 boys and 2 girls) reported that it was due to their individual interest and ability (Category 2), while three (all girls) thought that parental encouragement (Category 3) was the main reason. The following quotes illustrate these points:

> "*My teacher introduced the programming workshop in our computer lesson and encouraged us to join it as an extra-curricular activity. She said that we would use App Inventor to create our own apps.*" (Teacher encouragement, Interviewee 3)

> "*I like playing computer games. I thought that I would learn something new about how to create a computer game from the workshop, so I registered for the workshop and expected to build my own games using App Inventor.*" (Individual interest and ability, Interviewee 5)

> "*I registered for the workshop to design apps using App Inventor because my parents encouraged me to do so. They said that this workshop would be helpful to my study.*" (Parental encouragement, Interviewee 1)

The above qualitative results correspond closely to the quantitative findings that identify computer self-efficacy and external encouragement as important factors in influencing primary students to adopt VPE. It is shown that both male and female interviewees attributed VPE adoption to teacher encouragement and individual interest and ability, but only female interviewees reported parental encouragement as a motivating factor. The findings are consistent with the quantitative results that highlight the positive effects of external encouragement on girls' perceived usefulness and ease of use of VPE and, in turn, on behavioural intention to use VPE.

5.5.2. Perceived benefits and problems of VPE

When questioned about the benefits and problems of VPE, all interviewees recognised that VPE was a beneficial tool for developing usable and useful apps. However, some interviewees found VPE easy to use while some others did not. Two categories were identified to indicate students' perceived benefits of using VPE. Twenty-five students (20 boys and 5 girls) thought that VPE was useful to develop apps for sharing fun (Category 1). In addition, twenty students (18 boys and 2 girls) noted that VPE was easy to use because of its draggable blocks for programming (Category 2). The following quotes highlight the benefits:

"*I think it is good to use VPE because I can create funny games and make them available for use by others.*" (Apps development for sharing fun, Interviewee 10)

"*Building an app in VPE is similar to building Lego blocks. It is easy to add or remove Lego-like blocks to build simple apps*." (Draggable blocks for programming, Interviewee 8)

On the other hand, thirteen students (6 boys and 7 girls) responded that it was not easy to use VPE for building a functional app. Their problems with VPE can be grouped into two different categories: insufficient details of self-learning materials (Category 3) and limited support from teachers and parents (Category 4). The problems are raised below:

"*I was told to follow the instructions of the e-book to create a math game in class, but I failed to do it because some instructions were not clear enough ... I did not understand the meaning of some words on the blocks. I finally solved the problems by asking my classmates*." (Insufficient details of self-learning materials, Interviewee 16)

"*I followed the instructions of the e-book and created my app, but it did not work. My teacher was busy answering someone's questions, so I did not get a chance to seek advice from my teacher in class ... When I was back at home, I asked my parents how to fix my app but they could not help.*" (Limited support from teachers and parents, Interviewee 13)

The above qualitative results suggest that interviewees tended to perceive the usefulness of VPE rather than its ease of use, which replicate the results of the questionnaire survey. The results also suggest that external assistance (e.g. support from teachers and parents) is influential in determining students' perceived ease of use of VPE. This finding is in agreement with the quantitative results that there is a causal link between external assistance and perceived ease of use among boys and girls.

5.5.3. Motivating factors for continued use of VPE in future

Interviewees were finally asked what would make them continue to use VPE in future. Two categories of motivating factors for continued use of VPE were identified. Thirty interviewees (18 boys and 12 girls) answered that developing apps to serve their needs in an easy way (Category 1) would be a crucial factor. Moreover, eight interviewees (all boys) emphasised the importance of continued external assistance both in and out of class (Category 2). The following quotes illustrate these views:

"*I wish to create an easy-to-build app to turn my mBot into a robot fighter, and I would like to share the app with my friends so that we can join the robot fighting competition. If my teacher is going to teach me how to build such app, I will continue to use it [App Inventor]*" (Easy development of useful apps, Interviewee 5)

> "*If my teacher will teach me how to use App Inventor to create interesting apps in class and my parents will help me to solve my coding problems at home, I will be happy to use it*." (Continued external assistance in and out of class, Interviewee 13)

It is shown that the majority of interviewees would continue to use VPE if it could enable them to easily develop useful apps. This result is aligned with the quantitative findings that confirm the influence of students' perceived usefulness and ease of use of VPE on their behavioural intention to use it. Additionally, it is shown that only male interviewees underlined the association between external assistance and continued use of VPE. Based on the results of the quantitative analysis, external assistance has a positive effect on perceived ease of use, which can in turn affect behavioural intention among boys only. The qualitative findings, therefore, provide further support for gender differences in the determinants of behavioural intention to use VPE in the primary school context.

6. Conclusions and recommendations

There has been limited research into the issues of whether primary students accept VPE and whether gender differences exist in their acceptance of VPE, particularly in the Asia-Pacific region. To address the research gap, this study adopted a mixed method approach to explore primary students' acceptance of VPE in Hong Kong based on TAM. The findings from this study can contribute to a better understanding of the factors influencing the acceptance of VPE among boys and girls in the primary school context. Four external variables, namely computer self-efficacy, social influence, external assistance and external encouragement, were included in TAM to identify the determinants of perceived usefulness and perceived ease of use in the context of VPE. PLS-SEM was used to validate the proposed model and test the hypotheses derived from it.

In the analysis of external variables, the results of this study show that computer self-efficacy has significant effects on both perceived usefulness and perceived ease of use of VPE. They also show that external encouragement and external assistance are factors associated with perceived ease of use of VPE. These findings are consistent with the results of previous TAM studies (Joo et al., 2014; Nikou & Economides, 2017; Williams & Williams, 2010). This study additionally identifies gender differences in the effects of social influence and external encouragement, which were not taken into account for analysis in previous research (Hsiao et al., 2017; Vekiri & Chronaki, 2008). Evidence from this study indicates that social influence is more likely to impact on boys' perceived usefulness of VPE, while external encouragement tends to influence girls' perceived usefulness of VPE.

In the analysis of internal variables, two findings from this study are in contrast to those reported by previous TAM studies in higher education (Chow et al., 2012; Yeou, 2016). The first one is the insignificant impact of perceived ease of use on perceived usefulness in the context of this study. This suggests that primary students can perceive the usefulness of VPE even though they do not find it easy to use. The second is about gender differences in the determinants of behavioural intention to use VPE. This study indicates that either perceived usefulness of VPE or perceived ease of use of VPE can significantly influence behavioural intention to use VPE among boys. However, girls' behavioural intention to use VPE is determined by their attitude towards VPE and such attitude is influenced by both perceived usefulness and perceived ease of use.

Three recommendations for researchers and practitioners are made in regard to the findings of this study. First, it is found that computer self-efficacy is critical to developing primary students' positive views about the usefulness and ease of use of VPE. Since computer self-efficacy can be possibly enhanced by increasing computer use (Hsu & Huang, 2006), it is recommended that more class activities (e.g. STEM activities) and after-school events (e.g. coding clubs) can be organised to promote the use of computers for educational purposes. Second, it is found that external encouragement and external assistance are significant in influencing perceived ease of use. To help primary students overcome the difficulties in using VPE, it is recommended that continuous encouragement and assistance (e.g. guidance on how to use VPE to build an app) from both teachers and parents should be given to primary students in the course of programming. Lastly, it is found that perceived usefulness of VPE can be significantly affected by social influence among boys but by external encouragement among girls. Given gender differences in the determinants of perceived usefulness, it is recommended that instructional strategies can be specifically designed for boys (e.g. linking teacher expectations to student use of VPE) and for girls (e.g. providing timely and constructive feedback on student work in VPE) in programming education.

It is worthy to note that the findings of this study should be interpreted with caution since there are limitations associated with the study design. The data of this study were collected from primary schools in Hong Kong by convenience sampling. To generalise the findings, further studies should be carried out across different countries and should take account of the diversity in demographic and socioeconomic characteristics among participants. Moreover, this study was conducted in a programming workshop over a short duration and so participants might have limited exposure to VPE. Further research can be undertaken for a longer time frame. If more time could be given to students to use VPE, perhaps they would perceive more positively the usefulness and ease of use of VPE. Finally, App Inventor was adopted as the programming platform in this study. More work can be done to compare the results of various platforms and suggest which one is best suited for primary students.

References

Aho, A. V. (2012). Computation and computational thinking. *Computer Journal*, *55*, 832-835.

Akcaoglu, M. (2014). Learning problem-solving through making games at the game design and learning summer program. *Educational Technology Research and Development*, *62*(5), 583-600.

Akcaoglu, M., & Koehler, M. J. (2014). Cognitive outcomes from the game-design and learning (GDL) after-school program. *Computers & Education*, *75*, 72-81.

Alvarado, C., Dodds, Z., & Libeskind-Hadas, R. (2012). Increasing women's participation in computing at Harvey Mudd College. *ACM Inroads*, *3*(4), 55-64.

Bandura A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215.

Baser, M. (2013). Attitude, gender and achievement in computer programming. *Middle-East Journal of Scientific Research*, *14*(2), 248-255.

Bers, M. I., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education*, *72*, 145-157.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Carter, J., & Jenkins, T. (1999). Gender and programming: what's going on? *SIGCSE Bulletin*, *31*(3), 1-4.

Cheng, Y.-M., Lou, S.-J., Kuo, S.-H., Shih, R.-C. (2013). Investigating elementary school students' technology acceptance by applying digital game-based learning to environmental education. *Australasian Journal of Educational Technology*, *29*(1), 96-110.

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. In G. A. Marcoulides (Ed.), *Modern methods for business research*. Mahwah, NJ: Erlbaum, 295-336.

Chow, M., Herold, D. K., Choo, T.-M., & Chan, K. (2012). Extending the technology acceptance model to explore the intention to use Second Life for enhancing healthcare education. *Computers & Education*, *59*(4), 1136-1144.

Clement, D. H. (1991). Enhancement of creativity in computer environments. *American Educational Research Journal*, *28*(1), 173-187.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Mahwah, NJ: Lawrence Erlbaum.

Compeau, D. R., & Higgins, C. A. (1995). Computer self-efficacy: Development of a measure and initial test. *MIS Quarterly*, *19*(2), 189-211.

Daugherty, M. K. (2013). The prospect of an "A" in STEM education. *Journal of STEM Education: Innovations and Research*, *14*(2), 10-15.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319-340.

Davis, F., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, *35*(8), 982-1003.

Deng, X., Doll, W. J., Hendrickson, A. R., & Scazzero, J. A. (2005). A multi-group analysis of structural invariance: An illustration using the technology acceptance model. *Information & Management*, *42*, 745-759.

Education Bureau (2016). Report on promotion of STEM education: Unleashing potential in innovation. Retrieved from http://www.edb.gov.hk/attachment/en/curriculum-development/renewal/STEM%20Education%20Report_Eng.pdf

Elyazgi, M. G., Nilashi, M., Ibrahim, O., Rayhan, A., & Elyazgi, S. (2016). Evaluating the factors influencing e-book technology acceptance among school children using TOPSIS technique. *Journal of Soft Computing and Decision Support Systems*, *3*(2), 11-25.

Fessakis, G., Gouli, E., & Mavroudi, E. (2013). Problem solving by 5–6 years old kindergarten children in a computer programming environment: A case study. *Computers & Education*, *63*, 87-97.

Feurzeig, W., & Papert, S. A. (2011). Programming-languages as a conceptual framework for teaching mathematics. *Interactive Learning Environments*, *19*(5), 487-501.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Fornell, C., & Larcker, D. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*, 39-50.

Govender, I. (2009). The learning context: Influence on learning to program. *Computers & Education*, *53*, 1218-1230.

Grover, S., & Pea, R. (2013). Computational thinking in K-12: A review of the state of the field. *Educational Researcher*, *42*(1), 38-43.

Gu, X., Zhu, Y., & Guo, X. (2013). Meeting the "digital natives": Understanding the acceptance of technology in classrooms. *Educational Technology and Society*, *16*(1), 392-402.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). Thousand Oaks: Sage.

Henseler, J., Hubona, G., & Ray, P. A. (2016). Using PLS path modeling in new technology research: updated guidelines. *Industrial Management & Data Systems*, *116*(1), 2-20.

Henseler, J., Ringle, C., & Sinkovics, R. (2009). The use of partial least squares path modeling in international marketing. *Advances in International Marketing*, *20*, 277-319.

Hsiao, K.-L., Huang, T.-C., Chen, M.-Y., & Chiang, N.-T. (2017). Understanding the behavioral intention to play Austronesian learning games: From the perspectives of learning outcomes, service quality, and hedonic value. *Interactive Learning Environments.* Retrieved from http://www.tandfonline.com/doi/full/10.1080/10494820.2017.1333011.

Hsu, W.-K. K., Huang S.-H. S. (2006). Determinants of computer self-efficacy - An examination of learning motivations and learning environments. *Journal of Educational Computing Research*, *35*(3), 245-265.

Hsu, Y.-C., Rice, K., & Dawley, L. (2012). Empowering educators with Google's Android App Inventor: An online workshop in mobile app design. *British Journal of Educational Technology, 43*(1), E1-E5.

Hulland, J. (1999). Use of partial least squares (PLS) in strategic management research: a review of four recent studies. *Strategic Management Journal*, *20*(2), 195-204.

Joo, Y. J., Joung, S., Choi, S.-B., Lim, E., & Go, K. Y. (2014). Structural Relationships between variables of elementary school students' intention of accepting digital textbooks. In M. B. Nunes & M. McPherson (Eds.), *Proceedings of the International Conference on e-Learning 2014*, Lisbon, Portugal, July 15-19 (pp. 95-102). IADIS Press.

Kalelioglu, F. (2015). A new way of teaching programming skills to K-12 students: Code.org. *Computers in Human Behavior*, *52*, 200-210.

Kalelioglu, F., & Gulbahar, Y. (2014). The effects of teaching programming via Scratch on problem solving skills: A discussion from learners' perspective. *Informatics in Education*, *13*(1), 33-50.

Kazakoff, E., & Bers, M. (2012). Programming in a robotics context in the kindergarten classroom: The impact on sequencing skills. *Journal of Educational Multimedia and Hypermedia*, *21*(4), 371-391.

Kazakoff, E. R., Sullivan, A., & Bers, M. U. (2013). The effect of a classroom-based intensive robotics and programming workshop on sequencing ability in early childhood. *Early Childhood Education Journal*, *41*(4), 245-255.

Korkmaz, Ö. & Altun, H. (2013). Engineering and ceit student's attitude towards learning computer programming. *International Journal of Social Science*, *6*(2), 1169-1185.

Lai, C., Wang, Q., & Lei, J. (2012). What factors predict undergraduate students' use of technology for learning? A case from Hong Kong. *Computers & Education*, *59*(2), 569-579.

Lau, W. W. F., & Yuen, A. H. K. (2009). Exploring the effects of gender and learning styles on computer programming performance: Implications for programming pedagogy. *British Journal of Educational Technology*, *40*(4), 696-712.

Lee, I., Martin, F., Denner, J., Coulter, B., Allan, W., Erickson, J., Malyn-Smith, J., & Werner, L. (2011). Computational thinking for youth in practice. *ACM Inroads*, *2*(1), 32-37.

Lee, Y.-J. (2010). Developing computer programming concepts and skills via technology-enriched language-art projects: A case study. *Journal of Educational Multimedia and Hypermedia*, *19*(3), 307-326.

Lye, S. Y., & Koh, J. H. L. (2014). Review on teaching and learning of computational thinking through programming: What is next for K-12? *Computers in Human Behavior*, *41*, 51-61.

Malhotra, Y., & Galletta, D. (2005). A multidimensional commitment model of volitional systems adoption and usage behavior. *Journal of Management Information Systems, 22*(1), 117-151.

Marakas, G. M., Yi, M. Y., & Johnson, R. D. (1998). The multilevel and multifaceted character of computer self-efficacy: Toward clarification of the construct and an integrative framework for research. *Information Systems Research*, *9*(2), 126-163.

Martins, L. L., & Kellermanns, F. W. (2004). A model of business school students' acceptance of a web-based course management system. *Academy of Management Learning and Education, 3*(1), 7-26.

Mathieson, K. (1991). Predicting user intentions: comparing the TAM with the theory of planned behaviour. *Information Systems Research*, *2*(3), 173-191.

McFarland, D. J., & Hamilton, D. (2006). Adding contextual specificity to the technology acceptance model. *Computers in Human Behavior*, *22*(3), 427-447.

McGill, M. M. (2012). Learning to program with personal robots: Influences on student motivation. *ACM Transactions on Computing Education*, *12*(1), 4:1-4:32.

Meelissen, M. R. M., & Drent, M. (2008). Gender differences in computer attitudes: Does the school matter? *Computers in Human Behavior*, *24*(3), 969-985.

Nikou, S. A., & Economides, A. A, (2017). Mobile-based assessment: Investigating the factors that influence behavioural intention to use. *Computers & Education*, *109*, 56-73.

Özyurt Ö., & Özyurt, H. (2015). A study for determining computer programming students' attitudes towards programming and their programming self-efficacy, *Journal of Theory and Practice in Education*, *11*(1), 51-67.

Papert, S. (1993). *The children's machine: Rethinking school in the age of the computer*. New York, NY: Basic Books.

Pardamean, B., & Evelin (2014). Enhancement of creativity through logo programming. *American Journal of Applied Sciences*, *18*(4), 528-533.

Park, S. Y. (2009). An analysis of the technology acceptance model in understanding university students' behavioral intention to use e-learning. *Educational Technology & Society*, *12*(3), 150-162.

Resnick, M., Maloney, J., Monroy-Hernandez, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B., & Kafai, Y. (2009). Scratch: Programming for all. *Communications of the ACM*, *52*(11), 60-67.

Robins, A., Rountree, J., & Rountree, N. (2003). Learning and teaching programming: A review and discussion. *Computer Science Education*, *13*(2), 137-172.

Rubio, M. A., Romero-Zaliz, R., Mañoso, C., & de Madrid, A. P. (2015). Closing the gender gap in an introductory programming course. *Computers & Education*, *82*, 409-420.

Saxton, E., Burns, R., Holveck, S., Kelley, S., Prince, D., Rigelman, N., & Skinner, E. A. (2014). A common measurement system for K-12 STEM education: Adopting an educational evaluation methodology that elevates theoretical foundations and systems thinking. *Studies in Educational Evaluation*, *40*, 18-35.

Scott, J. E., & Walczak, S. (2009). Cognitive engagement with a multimedia ERP training tool: Assessing computer self-efficacy and technology acceptance. *Information & Management*, *46*(4), 221-232.

Shen, D., Laffey, J., Lin, Y., & Huang, X. (2006). Social influence for perceived usefulness and ease-of-use of course delivery systems. *Journal of Interactive Online Learning*, *5*(3), 270-282.

Shen, J., & Eder, L. B. (2009). Intentions to use virtual worlds for education. *Journal of Information System Education*, *20*(2), 225-233.

Smith, N., Sutcliffe, C., Sandvik, L. (2014). Code Club: bringing programming to UK primary schools through Scratch. *In Proceedings of 45th ACM Technical Symposium on Computer Science Education (SIGCSE 14)* (pp. 517–522). New York: ACM.

Sullivan, A., & Bers, M. U. (2016). Girls, boys, and bots: Gender differences in young children's performance on robotics and programming tasks. *Journal of Information Technology Education: Innovations in Practice*, *15*, 145-165.

Teo, T. (2009). Modelling technology acceptance in education: A study of pre-service teachers. *Computers & Education*, *52*(2), 302-312.

Terzis, V., & Economides, A. A, (2011). The acceptance and use of computer based assessment. *Computers & Education*, *56*, 1032-1044.

Thatcher, J. B., Zimmer, J. C., Gundlach, M. J., & McKnight, D. H. (2008). Internal and external dimensions of computer self-efficacy: An empirical examination. *IEEE Transactions on Engineering Management*, *55*(4), 628-644.

Vekiri, I., & Chronaki, A. (2008). Gender issues in technology use: Perceived social support, computer self-efficacy and value beliefs, and computer use beyond school. *Computers & Education*, *51*, 1392-1404.

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating perceived behavioral control, computer anxiety and enjoyment into the technology acceptance model. *Information Systems Research*, *11*(4), 342-365.

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, *39*(2), 273-315.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*(2), 186-204.

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review*, *92*(4), 548-573.

Williams, M., & Williams, J. (2010). Evaluating a model of business school students' acceptance of web-based course management systems. *International Journal of Management Education*, *8*(3), 59-70.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33-35.

Wold, H. (1985). Systems analysis by partial least squares. In P. Nijkamp, H. Leitner & N. Wrigley (Eds.), *Measuring the unmeasurable* (pp. 221-252). Dordrecht, Germany: Martinus Nijhoff.

Yang, T.-C., Hwang, G.-J., Yang, S. J. H., & Hwang, G.-H. (2015). A two-tier test-based approach to improving students' computer-programming skills in a web-based learning environment. *Educational Technology & Society*, *18*(1), 198-210.

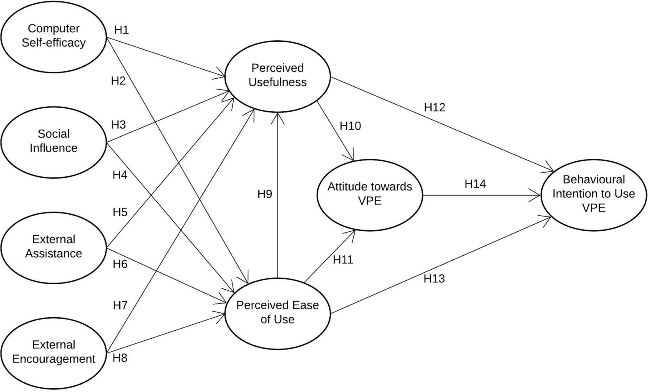
Yeou, M. (2016). An investigation of students' acceptance of Moodle in a blended learning setting using technology acceptance model. *Journal of Educational Technology Systems*, *44*(3), 300-318.

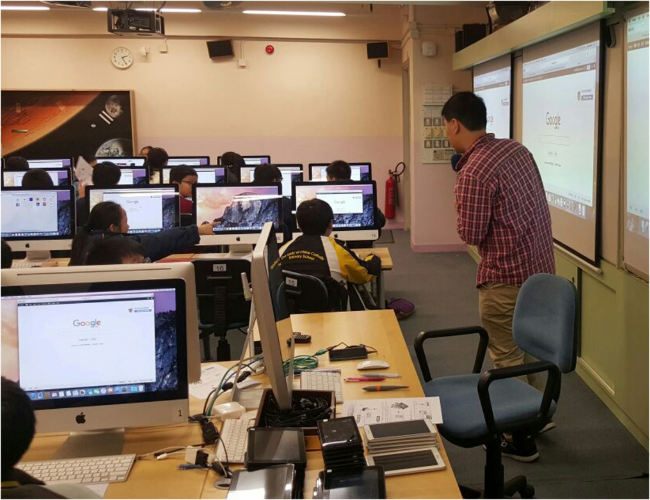
Yi, M. Y., & Hwang, Y. (2003). Predicting the use of web-based information systems: Self-efficacy, enjoyment, learning goal orientation, and the technology acceptance model. *International Journal of Human-Computer Studies*, *59*(4), 431-449.

Yousafzai, S. Y., Foxall, G. R., & Pallister, J. G. (2007). Technology acceptance: A meta-analysis of the TAM: Part 1. *Journal of Modelling in Management*, *2*(3), 251-280.

Highlights

- There is a lack of studies exploring gender and acceptance of VPE in primary schools
- Computer self-efficacy has the largest effect on students' perceptions of VPE
- Social influence tends to impact on boys' perceived usefulness of VPE
- External encouragement tends to impact on girls' perceived usefulness of VPE
- Gender differences in the determinants of behavioural intention to use VPE are found

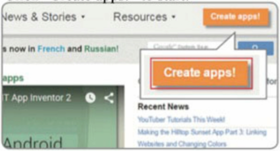

Computer Self-efficacy
Social Influence
External Assistance
External Encouragement
Perceived Usefulness
Perceived Ease of Use
Attitude towards VPE
Behavioural Intention to Use VPE
H1
H2
H3
H4
H5
H6
H7
H8
H9
H10
H11
H12
H13
H14


Google

教教你 Teaching you how to code

(一)開啟我的專案 (1) Open my project

① 進入App Inventor 2官方網站後，按「Create apps!」。
Click "Create apps!" to start.



② 輸入Google帳戶和密碼，然後按「登入」。To sign in, enter your Google username and password.

③ 在專案清單點選需要開啟的專案名稱，例如「TalkToMe」。
Select and open a project (e.g. "TalkToMe").

④ 成功開啟有關專案。
The project is opened successfully.

我們齊來把Talk To Me製成即時發聲工具吧！**Let us create an app that can speak!**

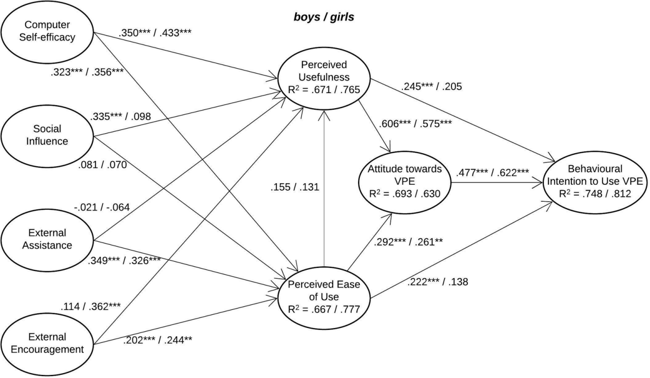

boys / girls
Computer Self-efficacy
Social Influence
External Assistance
External Encouragement
Perceived Usefulness R² = .671 / .765
Attitude towards VPE R² = .693 / .630
Perceived Ease of Use R² = .667 / .777
Behavioural Intention to Use VPE R² = .748 / .812
.350*** / .433***
.323*** / .356***
.335*** / .098
.081 / .070
-.021 / -.064
.349*** / .326***
.114 / .362***
.202*** / .244**
.155 / .131
.245*** / .205
.606*** / .575***
.477*** / .622***
.292*** / .261**
.222*** / .138

Table 1
Demographic information of participants.

Item	Category	Count (Percentage)	
		Male	Female
1. Total number of participants	--	296	135
2. Age (in years)	8	1 (0.3%)	5 (3.7%)
	9	26 (8.8%)	11 (8.1%)
	10	78 (26.4%)	28 (20.7%)
	11	122 (41.2%)	53 (39.3%)
	12 or above	69 (23.3%)	38 (28.1%)
3. Grade level	Primary 4	49 (16.6%)	27 (20.0%)
	Primary 5	118 (39.9%)	47 (34.8%)
	Primary 6	129 (43.6%)	61 (45.2%)
4. Number of hours spent on programming activities in the last four weeks (excluding the time taken for the programming workshop)	0	33 (11.1%)	20 (14.8%)
	1-5	184 (62.2%)	92 (68.1%)
	6-10	46 (15.5%)	16 (11.9%)
	11-15	16 (5.4%)	2 (1.5%)
	More than 15	17 (5.7%)	5 (3.7%)
5. Number of participating extra-curricular activities (except the programming workshop)	0	38 (12.8%)	11 (8.1%)
	1	41 (13.9%)	24 (17.8%)
	2	80 (27.0%)	30 (22.2%)
	3	58 (19.6%)	23 (17.0%)
	4 or above	79 (26.7%)	47 (34.8%)
6. Level of perceived academic competence	Below average	19 (6.4%)	12 (8.9%)
	Average	176 (59.5%)	81 (60.0%)
	Above average	101 (34.1%)	42 (31.1%)

Table 2
The questionnaire of student acceptance of VPE.

Construct	Item Code	Item	Reference
Computer self-efficacy (CSE)	CSE1 CSE2	I feel confident in using VPE. I have the knowledge and skills of using VPE.	Adapted from Park (2009)
Social influence (SI)	SI1 SI2 SI3	My parents or teachers think that I should use VPE. My classmates or friends think that I should use VPE. People who are important to me think that I should use VPE.	Adapted from Venkatesh & Davis (2000)
External assistance (EA)	EA1 EA2 EA3	My parents or teachers can help me use VPE. My classmates or friends can help me use VPE. I can seek help from people I know on problems in using VPE.	Adapted from Thatcher et al. (2008)
External encouragement (EE)	EE1 EE2 EE3	My parents or teachers encourage me to use VPE. My classmates or friends encourage me to use VPE. People who are important to me support using VPE.	Adapted from Martins & Kellermanns (2004)
Perceived usefulness (PU)	PU1 PU2 PU3	The use of VPE can help me understand knowledge of computer programming. The use of VPE can help me improve my performance in computer programming. The use of VPE can help me improve my academic achievement.	Adapted from Park (2009)
Perceived ease of use (PEOU)	PEOU1 PEOU2 PEOU3	I find VPE easy to use. It is easy to get VPE to do what I want it to do. It is easy to become skillful at using VPE.	Adapted from Venkatesh & Davis (2000)
Attitude towards VPE (AT)	AT1 AT2	Using VPE to learn about programming is a good idea. I like using VPE.	Adapted from Park (2009)
Behavioural intention to use VPE (BIU)	BIU1 BIU2	I intend to spend more time on using VPE. I intend to use VPE in future.	Adapted from Martins & Kellermanns (2004)

Table 3
An overview of the first workshop session.

Session:	1
Topic:	Introduction to App Inventor
Duration:	2 hours
Intended learning outcomes:	Upon completion of this session, participants should be able to: (1) Knowledge • understand the purpose of App Inventor • understand the user interface of App Inventor • understand the use of emulator (2) Skills • log into App Inventor • create and save a new project in App Inventor • build a simple app using programming blocks (3) Attitude: • develop their interest in programming • value the importance of logical thinking and creativity in programming
Class activities:	(1) Understand what App Inventor is (2) Run App Inventor on a Web browser (3) Change the interface language (4) Create and save a new project (5) Understand the user interface and programming blocks (6) Develop the ‘talk to me’ app (7) Run the emulator to test the ‘talk to me’ app on the computer

Table 4
Descriptive statistics of the questionnaire items for all participants (*N*=431).

Construct	Item	Male		Female	
		Mean	S.D.	Mean	S.D.
Computer self-efficacy (CSE)	CSE1	4.16	0.94	3.83	1.08
	CSE2	3.97	1.04	3.73	1.06
Social influence (SI)	SI1	4.00	1.05	3.81	1.06
	SI2	3.84	1.08	3.61	1.14
	SI3	3.77	1.03	3.57	1.00
Perceived usefulness (PU)	PU1	4.26	0.95	4.06	1.07
	PU2	3.81	1.13	3.37	1.10
	PU3	4.27	0.94	3.97	1.09
Perceived ease of use (PEOU)	PEOU1	3.65	1.23	3.38	1.17
	PEOU2	3.96	1.09	3.59	1.16
	PEOU3	3.54	1.24	3.40	1.15
External assistance (EA)	EA1	3.69	1.23	3.53	1.17
	EA2	3.58	1.26	3.53	1.19
	EA3	3.50	1.19	3.39	1.09
External encouragement (EE)	EE1	3.98	1.10	3.81	1.07
	EE2	3.75	1.19	3.66	1.13
	EE3	3.73	1.10	3.62	1.00
Attitude towards VPE (AT)	AT1	4.26	0.93	3.89	1.14
	AT2	4.21	0.95	3.82	1.20
Behavioral intention to use VPE (BIU)	BIU1	4.05	1.02	3.70	1.15
	BIU2	4.17	0.99	3.74	1.15

Table 5
Reliability and convergent validity of constructs in the measurement model for boys (*N*=296).

Construct	Item	Factor loading	Composite reliability	Average variance extracted
Computer self-efficacy (CSE)	CSE1	.943	.939	.886
	CSE2	.939		
Social influence (SI)	SI1	.903	.957	.883
	SI2	.923		
	SI3	.990		
External assistance (EA)	EA1	.925	.965	.901
	EA2	.929		
	EA3	.993		
External encouragement (EE)	EE1	.913	.960	.890
	EE2	.924		
	EE3	.991		
Perceived usefulness (PU)	PU1	.878	.896	.742
	PU2	.818		
	PU3	.888		
Perceived ease of use (PEOU)	PEOU1	.904	.900	.750
	PEOU2	.871		
	PEOU3	.822		
Attitude towards VPE (AT)	AT1	.968	.968	.938
	AT2	.969		
Behavioral intention to use VPE (BIU)	BIU1	.926	.926	.861
	BIU2	.931		

Table 6
Reliability and convergent validity of constructs in the measurement model for girls (*N*=135).

Construct	Item	Factor loading	Composite reliability	Average variance extracted
Computer self-efficacy (CSE)	CSE1	.950	.949	.903
	CSE2	.951		
Social influence (SI)	SI1	.907	.954	.875
	SI2	.907		
	SI3	.990		
External assistance (EA)	EA1	.891	.952	.869
	EA2	.911		
	EA3	.992		
External encouragement (EE)	EE1	.892	.947	.856
	EE2	.889		
	EE3	.991		
Perceived usefulness (PU)	PU1	.905	.907	.764
	PU2	.814		
	PU3	.901		
Perceived ease of use (PEOU)	PEOU1	.902	.912	.776
	PEOU2	.878		
	PEOU3	.862		
Attitude towards VPE (AT)	AT1	.969	.969	.940
	AT2	.970		
Behavioral intention to use VPE (BIU)	BIU1	.959	.956	.916
	BIU2	.955		

Table 7
Discriminant validity for the constructs of the measurement model for boys (*N*=296).

Construct	CSE	SI	EA	EE	PU	PEOU	AT	BIU
Computer self-efficacy (CSE)	**.941**							
Social influence (SI)	.664	**.939**						
External assistance (EA)	.565	.637	**.949**					
External encouragement (EE)	.534	.771	.708	**.943**				
Perceived usefulness (PU)	.727	.746	.584	.650	**.862**			
Perceived ease of use (PEOU)	.682	.674	.726	.684	.682	**.866**		
Attitude towards VPE (AT)	.721	.645	.526	.627	.805	.705	**.968**	
Behavioral intention to use VPE (BIU)	.702	.659	.601	.682	.780	.725	.831	**.928**

Table 8
Discriminant validity for the constructs of the measurement model for girls (*N*=135).

Construct	CSE	SI	EA	EE	PU	PEOU	AT	BIU
Computer self-efficacy (CSE)	**.950**							
Social influence (SI)	.652	**.935**						
External assistance (EA)	.648	.679	**.932**					
External encouragement (EE)	.676	.839	.754	**.925**				
Perceived usefulness (PU)	.802	.736	.659	.792	**.874**			
Perceived ease of use (PEOU)	.778	.728	.788	.789	.774	**.881**		
Attitude towards VPE (AT)	.726	.714	.634	.743	.777	.706	**.969**	
Behavioral intention to use VPE (BIU)	.691	.728	.627	.717	.795	.736	.879	**.957**

Table 9
Evaluation results of the structural model for boys (*N*=296).

Hypothesis	Path	Path coefficient	f^2 effect size	*t* value	Hypothesis supported?
H1	CSE → PU	.350	.167	4.663^{***}	Yes
H2	CSE → PEOU	.323	.164	4.803^{***}	Yes
H3	SI → PU	.335	.107	4.139^{***}	Yes
H4	SI → PEOU	.081	.006	0.961	No
H5	EA → PU	-.021	.001	0.289	No
H6	EA → PEOU	.349	.164	5.957^{***}	Yes
H7	EE → PU	.114	.012	1.233	No
H8	EE → PEOU	.202	.040	2.808^{***}	Yes
H9	PEOU → PU	.155	.024	1.946	No
H10	PU → AT	.606	.640	11.773^{***}	Yes
H11	PEOU → AT	.292	.149	6.149^{***}	Yes
H12	PU → BIU	.245	.078	4.021^{***}	Yes
H13	PEOU → BIU	.222	.092	4.113^{***}	Yes
H14	AT → BIU	.477	.278	6.528^{***}	Yes

$^{**}p < .05$, $^{***}p < .01$

Table 10
Evaluation results of the structural model for girls (N=135).

Hypothesis	Path	Path coefficient	f^2 effect size	t value	Hypothesis supported?
H1	CSE → PU	.433	.301	5.169***	Yes
H2	CSE → PEOU	.356	.274	5.070***	Yes
H3	SI → PU	.098	.011	1.093	No
H4	SI → PEOU	.070	.006	0.780	No
H5	EA → PU	-.064	.006	0.695	No
H6	EA → PEOU	.326	.188	4.551***	Yes
H7	EE → PU	.362	.118	3.769***	Yes
H8	EE → PEOU	.244	.060	2.313**	Yes
H9	PEOU → PU	.131	.016	1.441	No
H10	PU → AT	.575	.359	4.303***	Yes
H11	PEOU → AT	.261	.074	1.984**	Yes
H12	PU → BIU	.205	.066	1.860	No
H13	PEOU → BIU	.138	.038	1.904	No
H14	AT → BIU	.622	.760	7.612***	Yes

**$p < .05$, ***$p < .01$