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ORIGINAL PAPER

Using Lego NXT to explore scientific literacy in disaster prevention and rescue systems

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Abstract This study explores the effectiveness of disaster prevention programs using NXT control techniques. The purpose of the cultivation of scientific literacy is to develop a more rational, scientific perspective on the current social changes and the impact of natural disasters. Using NXT as an effective scientific tool to support science education, we can further explore science education for the development of scientific literacy. The expectation confirmation model and technology acceptance model are used to explain the effect of technology products on the user's satisfaction and intention. However, for the interpretation of scientific literacy, there is a lack of environmental and cognitive factors. So we combine social cognitive theory with social and scientific theories in our exploration of the use of NXT for the dominant effect of scientific literacy. The results demonstrate that users' self-efficacy and the ease of use of NXT have low significance on use of scientific tools, but, at the end, it did not affect the user wishes. The interactions of NXT features and climate are the main causes of enhanced user intentions. Therefore, environmental factors are identified as an important reason for the development of scientific literacy. The results of this study on scientific literacy stimulate more directions for discussion.

Keywords Social cognitive theory (SCT) · Expectation confirmation model (ECM) · Technology acceptance model (TAM) · Disaster prevention · Risk aversion

1 Introduction

Science education uses a variety of scientific instruments or methods. The purpose is to let the learner achieve good effectiveness in learning, providing an effective tool that is able to attract and satisfy students (Wrzesien and Raya 2010). Effective tools for student learning lead to a significant effect.

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In recent years, science education has been accepted among the important disciplines by millions of people around the world. As for an effective means to use science and technology to assist in teaching, Lego NXT is the best choice. The root of Lego NXT roots in the Robotics Invention System kit was created at the MIT Media Lab (Rusk et al. 2008). It is a programmable brick suitable for all ages and also holds more related games than anywhere else in the world. It can promote students' skills in critical thinking through hands-on learning (Ranganathan et al. 2008), Lego NXT, through a high degree of liberalization, has become an effective teaching medium. The cognitive abilities and expectations about learning to help students use games which contain educational objectives and subjects to render learning has great potential in academic subjects (Papastergiou 2008).

In 2011, there were many natural disasters (e.g. earthquakes, tsunamis, hurricanes, volcanic eruptions) around the world; in particular, the Japan 9.0 earthquake also triggered more disasters. Therefore, in many areas, the expansion of scientific literacy has become the focus of science education research.

Scientific literacy is the capacity to develop basic education. In the United States, many educational institutions (American Association for the Advancement of Science (AAAS) and United States National Center for Education Statistics) regard it as the focus of national training. In Taiwan, it is also regarded as the basic education of natural sciences areas. Science literacy focuses on distinguishing scientific issues, explaining scientific phenomena and using scientific evidence (Schneider 2007). The purpose is to culture citizens to meet social expectations. Therefore, scientific literacy is a concept of integration of social (Van Eijck and Roth 2010) and scientific (Özgelen and Yilmaz-Tuzun 2007; Srbinovski et al. 2010). The use of social and scientific theories is combined with scientific tools in order to determine the user's ability of scientific literacy.

Science education has been recognized as having a number of advantages (e.g. strengthening traditional education and heightening learning courses and outcomes (Rutten et al. 2011)). But the factors (attitudes, social norms and performing of behavior) may give rise to changes in individual intention to use science education (Kennedy-Clark 2011). Thus, we believe science technology coordinated social factors is a useful subject to investigate in relation to scientific literacy.

Our research model is based on three theoretical foundations SCT, ECM, and TAM; we merge those three theories for several reasons. First, the effective tool would affect individual intention to learn academic subjects, quote from Papastergiou (2008) the cognitive abilities and expectations to learning. The cognitive abilities use the social cognitive theory (SCT), which is considered able to predict and explain the importance of behavior theory, personal and environmental interaction that affect subsequent behavior and intention (perceived usefulness) (Bandura 1986). In other expectations that the expectation confirmation model (ECM) is used to investigate the information technology (IT) of perceived usefulness by confirmation experience (Bhattacherjee 2001a, b), we hope to explore what personal experiences might be used in the future, so in this section we use the ECM and SCT to aid support. Second, scientific literacy is related to ease to use and usefulness by IT. The TAM proposes two key beliefs: perceived usefulness and perceived ease of use (Davis et al. 1989); easy to use programs will affect attitude and intention to use. Third, the three theories of the perceived usefulness factor have improved support; integration of unified research models has a better explanation (Lee 2010); and unified models will be able to interpret increased use of IT which can be used to further explore science education.

With the effectiveness of the Lego NXT science education tools, the support of scientific theory, and the application of science education with IT research to scientific literacy, scientific literacy has been able to affect the living environment, in relation to the natural environment and natural disasters.

2 Theoretical foundation and hypotheses

We use the theoretical foundation of the SCT, ECM, and technology acceptance model (TAM). In this paper, our objective is to discuss the personal intentions and individual behavior with the effective tools for science education one intends to use and the research of scientific literacy.

2.1 SCT

The SCT is consistent with our theoretical framework. The SCT was proposed by Bandura (1977) and integrated the complete theoretical framework from behaviorism through observations of people learning in day-to-day life. It relies on three linked factors, people, environment, and behavior, as the interaction-related determinant (Bandura 1986). Hence, the theoretical hypothesis of performance expectations and self-efficacy and these two factors are the critical aspect of individual behavior (Compeau and Higgins 1995; Compeau et al. 1999). The performance expectation is whether users receive the expected effect through past experience with the tools for science education. The product of personal use from the performance expectations is perceived usefulness on ECM (Bhattacherjee 2001a, b).The concept of self-efficacy is studied by different subjects, where people have control over events that affect them (Bandura 1995). To use Lego NXT for self-efficacy could change this into IT for computer self-efficacy.

The traditional educational environment is built on the foundation of social and physical environments (Piccoli et al. 2001; Ai-Hazimi et al. 2004). In science education, the physical environments are treated as technological factors, in the discussion of the variety of functions of Lego NXT. The technological environment is comprised of system functionality and content features; these are important factors to create the appropriate scientific tools. The social environment is comprised of interactions and learning climate. It is

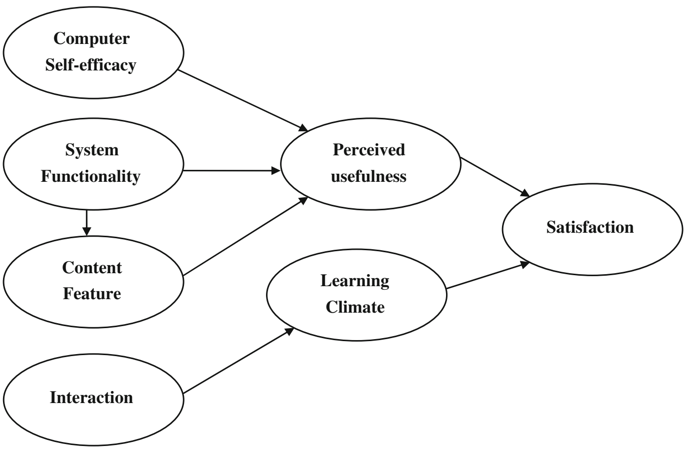


Fig. 1 Model of Social cognitive theory (SCT)

related to the interaction between teachers and students in the atmosphere of science education. A model is shown in Fig. 1.

Based on the expectancy–confirmation theory, perceived IT usefulness with satisfaction is effective (Oliver 1980). Many studies confirm that perceived usefulness has influence on satisfaction in IT (Compeau and Higgins 1995). In addition, personal cognitive factors also affect computer self-efficacy, meaning people have differences in influence by control over events (Shih 2006; So and Brush 2008). Mastery of the computer will help with perceived usefulness, so we assume that computer self-efficacy is related to perceived usefulness.

H1 Users' perceived usefulness of Lego NXT use is positively associated with satisfaction with Lego NXT.

H2 Individual's computer self-efficacy is positively associated with perceived usefulness of Lego NXT use.

Next, the environment includes technical and social factors. First, the technical environment contains system functionality and content features, have a rich variety of media and course materials (divided into system functionality and content features). It is presumed to be a key factor to acceptance by users (Liu et al. 2009), and richness of media is related to perceived usefulness. The content feature factor is also related to the function of the system strength. Therefore, system functionality can also affect the content features (Lee et al. 2009; So and Brush 2008).

H3 System functionality of Lego NXT is positively associated with perceived usefulness for a higher level of use.

H4 System functionality in Lego NXT is positively associated with content features in Lego NXT.

H5 Content features in Lego NXT are positively associated with perceived usefulness for Lego NXT use.

Second, the social environment includes interactions and learning climate. The interactions between teacher and student with their peer' communication, and mutual teaching may enhance the willingness to learn (Solimeno et al. 2008). The mutual collaboration effect between teacher and student creates a good learning climate (Walberg and Anderson 1968). Instructors' immediacy behaviors (Creating learning climate) have a major effect on their students' satisfaction, learning, and motivation (Paechter et al. 2010).

H6 Interaction is positively associated with perceived usefulness for Lego NXT use.

H7 Interaction is positively associated with learning climate.

H8 Learning climate is positively associated with satisfaction with Lego NXT.

2.2 Expectation confirmation model (ECM)

The ECM explains the performance expectations of people who used the personal product (Oliver 1980; Limayem and Cheung 2008). However, it requires some theories to clarify personal behavior in using the science education tools. Therefore, the model focused on observing the changes after use; the expectations are related to satisfaction and usage intention. If use of the tools of science education could be heightened, it will be possible to explain the users' personal behavior. Hence, after use expectation is characterized from perceived usefulness, which is a cognitive ability salient to tools for science education and consistent with scientific literacy.

Then Bhattacherjee (2001a, b) proposed that individual decisions after use would affect the user's confirmation of expectations, through expectations of perceived usefulness. This changes the performance expectations of the SCT to perceived usefulness. This is the model of the formation of ECM in Fig. 2.

Users have expectations toward the product before its purchase, and its usage experience after using it. Whether or not the usage experience confirms these expectations will determine the user's will to purchase the product again (Oliver 1980; Gallarza et al. 2011). Perceived usefulness is adjusted based on confirmatory experience. When the perceived usefulness is not clear, the uncertainty generated is expected with the use of IT (Bhattacherjee 2001a, b). Hence, perceived usefulness is a significant predictor of both perceived enjoyment and intention to use IT (Davis et al. 1989; Saade and Bahli 2005; Teo and Noyes 2011).

H9 Satisfaction is positively related to Lego NXT usage intention.

H10 Confirmation of expectations is positively related to a student's satisfaction with Lego NXT.

H11 Perceived usefulness of Lego NXT is positively related to Lego NXT usage intention.

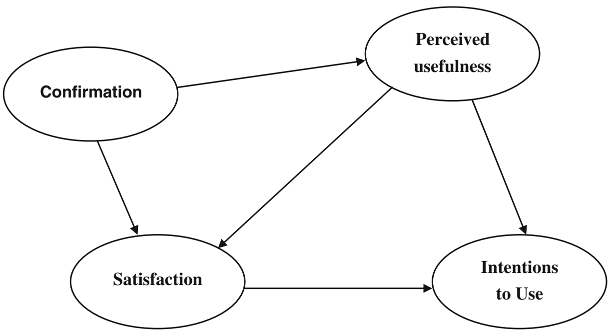
H12 Confirmation of expectations is positively related to their perceived usefulness with Lego NXT.

2.3 Technology acceptance model (TAM)

The theoretical discussion about perceived usefulness and perceived ease of use prompts the behavior to continue using the product (Davis et al. 1989; Ha and Stoel 2009; Gagnon et al. 2011). Many forms of IT apply this model to verify whether it is used, such as the impact of media richness on technology acceptance (Liu et al. 2009). Further, as a theoretical basis for TAM, the perceived ease of use of tools for science education is expected to directly and indirectly influence perceived usefulness and affect scientific tools usage intention. For an illustration of the model, see Fig. 3.

Perceived usefulness and perceived ease of use determine the attitude of the user. We investigate perceived ease of use in this study and find that along with the perceived usefulness it has a positive impact (Davis et al. 1989; Walczuch et al. 2007). Positive

Fig. 2 Expectation confirmation model (ECM)



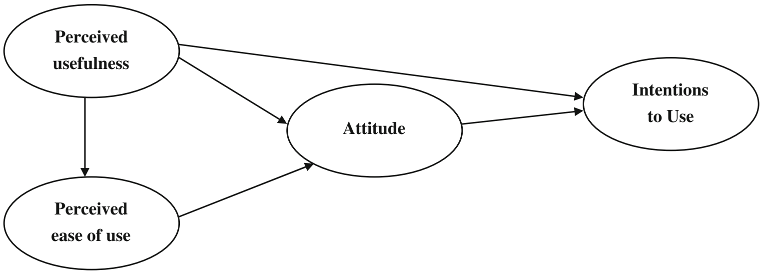


Fig. 3 Technology acceptance model (TAM)

attitude can promote to use of technology, and optimists are more willing to use IT (Scheier and Carver 1987).

H13 Perceived usefulness is positively related to behavioral attitude with Lego NXT.

H14 Perceived ease of use is positively related to behavioral attitude with Lego NXT.

H15 Perceived ease of use is positively related to perceived usefulness of Lego NXT.

H16 Behavioral attitude with Lego NXT is positively related to the continued intention to use Lego NXT.

With the same line of models, we can view the relationship between personal intentions and individual behavior from different points. The SCT is from an environmental perspective, the ECM from the cognition and expectations perspective, and the TAM from ease of use to enhance learning through tools for science education. In fact, the TAM has similar environmental factors or external factors. The external factors include perceived usefulness and perceived ease of use (Van Raaij and Schepers 2008; Liu et al. 2009), but the detailed causes of a wide range of external factors cannot be explained. For scientific literacy, which is the concept of a social nature (Van Eijck and Roth 2010), we can use technology and social environmental factors to study the impact of more specific reasons. Since models are designed to explain different perspectives of users' intentions, the extended models may provide a more complete explanation of tools for science education usage behavior by combining these models (Hong et al. 2006; Venkatesh et al. 2011). See Fig. 4 for an outline of the theoretical model and hypotheses.

3 Methodology

Participants use Lego NXT as a tool for science education to explore the scientific literacy of users.

3.1 Pre-test

Preliminary data were collected using questionnaires by random sampling. There were 146 responses, of which 140 were effective, giving an effectiveness rate of 95 %. Predicted results were evaluated on a five-point Likert-type scale ranging from "strongly agree" to "strongly disagree," given 5-1 points to use in an analysis. The coefficient was calculated with the standard lower bound for factor loading set at 0.5, with unqualified question items

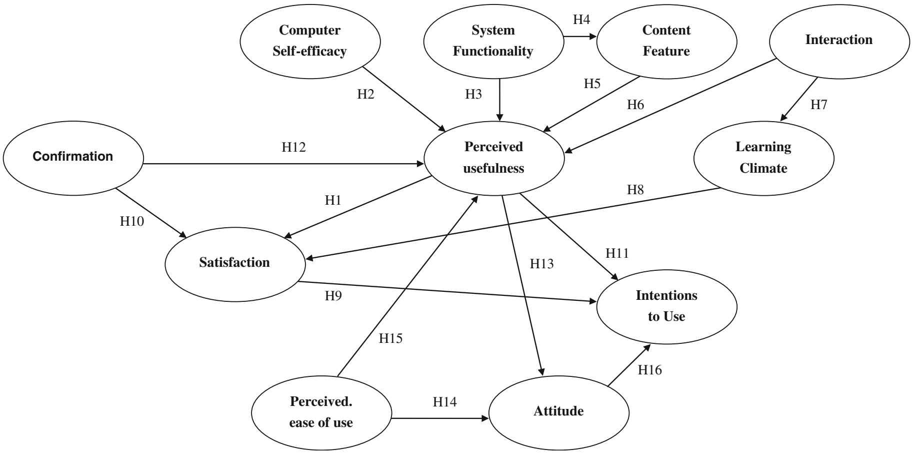


Fig. 4 Theoretical model and hypotheses

being eliminated. Inspection of the question items, the entire questions, and the wording was conducted to confirm their appropriateness and whether the semantic content was clear or not. Wrong answers would affect the validity of the questionnaire.

3.2 Participants

The survey was distributed from university students to elementary school students. The targets were intentionally selected for Lego NXT based on their experience, since if the use of Lego NXT is suitable for a student, that student's learning will be more suitable for exploring scientific literacy. Data were collected using paper-based questionnaires for the sake of sampling convenience (Table 1).

3.3 Data collection procedure

The study sample was taken from questionnaire surveys of students who used Lego NXT for learning. Science education can be performed through the use of many technologies. Lego NXT offers a high degree of freedom for users and subjects, facilitated by effective tools for science education. In contrast, the traditional teaching or use of single function teaching aids makes it difficult to inspire students in scientific literacy. For this study, Lego

Table 1 Participant statistics

Variables	Classification	Number	Percent
Gender	Male	124	72
	Female	48	28
Age	6–12	89	51.7
	13–19	63	36.6
	20–25	17	9.9
	>25	3	1.8
Total		172	100

NXT was used both in actual applications and in the curriculum, and the users were required to answer questions based on their usage experience.

In total, 193 questionnaires were distributed to students who had used Lego NXT. Returned questionnaires that were missing answers or incomplete had to be discarded, and 172 valid questionnaires were returned. By gender, 72 % of the participants were male, and 28 % were female. The age statistics of the target objective were 6–12 (51.7 %), 13–19 (36.6 %), 20–25 (9.9 %) and above 25 (1.8 %). Questionnaire items included only a simple survey of the population constructs, because the participants had experience using Lego NXT.

3.4 Instrumentation

In this study, the partial least squares (PLS) method was used for the data analysis. PLS is a common method for latent variable statistical, often used to verify the validity of the structure and assess the structural relationship between the factors (Chin 1998; Gefen and Straub 2005). The analytical method is suitable for predictive research models focused on theory development. It proposes confirmation of analysis and demands for the creation of a model matched with assumptions (Joreskog and Wold 1982; Gefen and Straub 2005; Bagozzi and Yi 2012).

4 Results

Anderson and Gerbing (1988) proposed two suggested steps in their analytical figures: first, examine the measures for convergence and discriminant validity using the measurement model, and then, survey the structural model in the theoretical hypotheses to determine whether they have the strength and direction or not.

4.1 Measurement model

Convergent validity was used to assess the factors assumed in line with the standard indicator. Following Fornell and Larcker (1981)'s recommendation, we evaluated the measurement scales, the item factor loadings (k) should be greater than 0.5, and our indicator values ranged from 0.754 to 0.910 within the standards. Then, construct reliabilities (should exceed 0.8) serve as construct indicators of internal consistency, and the higher indicators display indicate greater consistency average variance extracted (should exceed 0.5) signifying that the indicator can be used to explain more variance. The internal items' reliability and consistency taking Cronbach's alpha inspection should exceed 0.7 (Guielford 1965; Nunnally 1978). These standards of measurements have been achieved, as shown in Table 2. The construct reliabilities range from 0.844 to 0.919, the AVE range from 0.643 to 0.823, and the Cronbach's alpha range from 0.712 to 0.880. Therefore, the convergent validity allows for conformed measurement with this model. The factor structure matrix of loadings and cross-loadings are shown in Appendix.

We discriminate the validity to assess different concept indicators with another connection indicator (Bagozzi et al. 1991; Compeau et al. 1999). All of the factors have a latent variable (square root of AVE) greater than the correlations between other factors (Fornell and Larcker 1981). In this model, the diagonal square root exceeded any non-diagonal ones, as shown in Table 3, and thus, the measurement is affirmatory that our model had high reliability.

Table 2 Convergent validity of measurement model

Construct	Indicator	Loading	Composite reliability (CR)	AVE	Cronbach alpha
CSE		0.801	0.844	0.643	0.712
	CSE1	0.754			
	CSE2	0.847			
	CSE3	0.803			
SF		0.907	0.903	0.823	0.783
	SF1	0.904			
	SF2	0.91			
CF		0.84	0.879	0.707	0.793
	CF1	0.826			
	CF2	0.886			
	CF3	0.81			
INT		0.88	0.873	0.775	0.712
	INT1	0.861			
	INT2	0.9			
PU		0.848	0.911	0.719	0.87
	PU1	0.853			
	PU2	0.839			
	PU3	0.85			
	PU4	0.849			
LC		0.864	0.898	0.746	0.83
	LC1	0.856			
	LC2	0.865			
	LC3	0.87			
SAT		0.821	0.892	0.674	0.837
	SAT1	0.815			
	SAT2	0.821			
	SAT3	0.804			
	SAT4	0.843			
CON		0.863	0.897	0.744	0.826
	CON1	0.88			
	CON2	0.877			
	CON3	0.831			
ITU		0.859	0.919	0.739	0.88
	ITI1	0.887			
	ITU2	0.89			
	ITU3	0.856			
	ITI	0.804			
ATT		0.888	0.918	0.789	0.866
	ATT1	0.889			
	ATT2	0.91			
	ATT3	0.866			

Table 2 continued

Construct	Indicator	Loading	Composite reliability (CR)	AVE	Cronbach alpha
PFU		0.838	0.905	0.704	0.859
	PFU1	0.814			
	PFU2	0.813			
	PFU3	0.835			
	PFU14	0.892			

Table 3 Correlation of discriminant validity

–	CSE	SF	CF	INT	PU	LC	SAT	CON	ITU	ATT	PEU
CSE	**0.844**										
SF	0.723	**0.885**									
CF	0.728	−0.706	**0.890**								
INT	0.670	−0.728	0.761	**0.844**							
PU	0.690	−0.824	0.783	−0.759	**0.933**						
LC	0.741	−0.736	0.842	−0.791	0.811	**0.911**					
SAT	0.742	−0.751	0.835	−0.788	0.838	0.825	**0.915**				
CON	0.765	−0.776	0.812	−0.731	0.802	0.814	0.842	**0.909**			
ITU	0.736	−0.705	0.840	−0.757	0.775	0.829	0.829	0.828	**0.938**		
ATT	0.729	−0.739	0.791	−0.799	0.769	0.855	0.831	0.845	0.859	**0.931**	
PEU	0.758	−0.752	0.767	−0.713	0.726	0.777	0.768	0.783	0.738	0.761	**0.927**

4.2 Structural model

The structural model was verified by suing the PLS to analyze the path structure of the *p* value and explained variance (R^2value).

The bootstrap technique was used to explain path significance. It allows us to estimate to parameter vectors, and was used for parameter means, standard errors, factor loadings and weights (Lohmoeller 1984). It is appropriate for use in IT studies (Chin and Gopal 1995; Hulland 1999). We used the above method for testing model hypotheses and corollaries. The estimated path structural coefficient and its link with each specified construct correlation and the structural model of the results analysis are show in Fig. 5.

The R^2 value path models explained the importance of the value indicators of predictability observed (Barclay et al. 1995; Chin and Gopal 1995). The *p* value is commonly used to determine the general acceptance and rejection of the null hypothesis, and show the degree of confidence in the results. We found most of the coefficients and path parameters are significant in this study.

4.3 Hypotheses testing

Each of the Hypotheses provides further path coefficients to take the direct, indirect, and total effects to demonstrate in support, as shown in Table 4. Finally, each hypothesis constructs the path and the support status, as shown in Table 5.

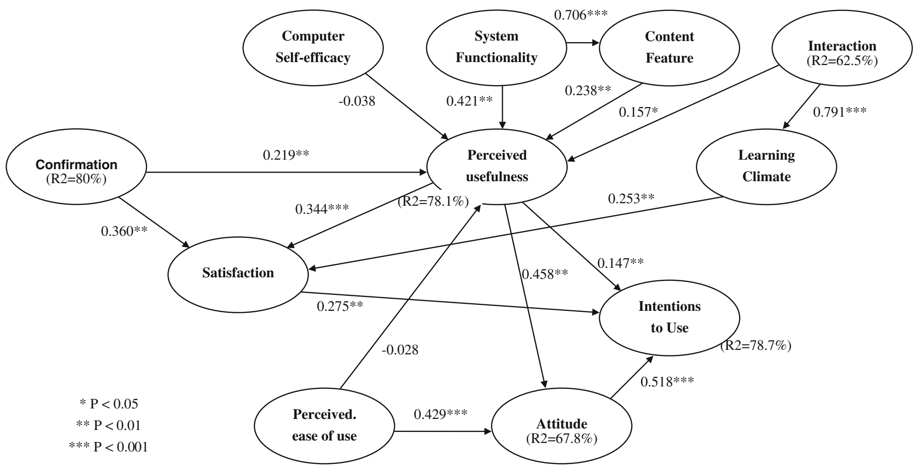


Fig. 5 Structural analysis results model

Table 4 Standardized causal effects

Latent variables		Standardized causal effects		
Dependent	Independent	Direct	Indirect	Total
Content feature	System functionality	0.706		0.706
Learning climate	Interaction	0.791		0.791
Attitude	Perceived usefulness	0.458		0.458
	Perceived ease of use	0.429		0.429
Perceived usefulness	Computer self-efficacy	−0.038		−0.038
	System functionality	0.421	0.168	0.589
	Content feature	0.238		0.238
	Interaction	0.157		0.157
	Confirmation	0.219		0.219
	Perceived ease of use	−0.028		−0.028
Satisfaction	Confirmation	0.36		0.360
	Perceived usefulness	0.344		0.344
	Learning climate	0.147		0.147
Intentions to use	Computer self-efficacy		−0.006	−0.006
	System functionality		0.087	0.087
	Content feature		0.035	0.035
	Interaction		0.055	0.055
	Learning climate		0.040	0.040
	Confirmation		0.131	0.131
	Satisfaction	0.275		0.275
	Perceived ease of use		0.222	0.222
	Perceived usefulness	0.147	0.332	0.479
	Attitude	−0.028		−0.028

Table 5 Summary of hypotheses testing

Hypotheses	Path	β	p value	Support
H1	PU → SAT	0.344	–***	Yes
H2	CSE → PU	−0.038	0.3195	No
H3	SF → PU	0.421	–***	Yes
H4	SF → CF	0.706	–***	Yes
H5	CF → PU	0.238	0.0227**	Yes
H6	INT → PU	0.157	0.0584*	Yes
H7	INT → LC	0.791	–***	Yes
H8	LC → SAT	0.147	0.0102**	Yes
H9	SAT → ITU	0.275	0.0046**	Yes
H10	CON → SAT	0.36	–***	Yes
H11	PU → ITU	0.147	0.0374**	Yes
H12	CON → PU	0.219	0.0414**	Yes
H13	PU → ATT	0.458	–***	Yes
H14	PEU → ATT	0.429	–***	Yes
H15	PEU → PU	−0.028	0.6627	No
H16	ATT → ITU	0.518	–***	Yes

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

For the SCT model, the cognitive factors, such as H1 ($\beta = 0.344$, $\rho < 0.01$), demonstrate that the perceived usefulness has an effect on satisfaction, but H2 ($\beta = -0.038$) shows that computer self-efficacy has no effect on perceived usefulness. That is to say, the user who perceives usefulness will evince satisfaction, but computer self-efficacy is not a significant factor.

Next, the technological environment factors, H3 ($\beta = 0.421$, $\rho < 0.001$), H4 ($\beta = 0.406$, $\rho < 0.001$), and H5 ($\beta = 0.238$, $\rho < 0.01$) form a significant path. System functionality and content features directly affect the user's perceived usefulness. In addition, the Lego NXT system functionality is directly related to its Content features, so it also indirectly affects perceived usefulness. This proves that effective tools for science education cannot rely only on content, and they require good auxiliary system functionality.

Next, the social environment factors, H6 ($\beta = 0.1571$, $\rho < 0.05$), H7 ($\beta = 0.791$, $\rho < 0.001$) and H8 ($\beta = 0.147$, $\rho < 0.01$), are also a significant path. The interaction has a direct effect on perceived usefulness and learning climate. For users, a good interactive learning atmosphere is better. H8, the learning climate, directly affects user satisfaction; the coefficients demonstrate this to be a significant support.

In addition to the ECM model, all hypotheses (H9, H10, H11, and H12) are significant. They have a confirmatory effect on satisfaction (H10, $\beta = 0.360$, $\rho < 0.001$) and perceived usefulness (H12, $\beta = 0.1571$, $\rho < 0.01$). However, these two factors (H9, $\beta = 0.275$, $\rho < 0.01$; H11, $\beta = 0.147$, $\rho < 0.01$) also have a direct effect on intentions to use. Therefore, such a path makes confirmation with perceived usefulness indirectly affecting intention to use. However, there is an interesting phenomenon that perceived usefulness has stronger indirect effects than direct effects. It seems that most factors influence perceived usefulness, so the indirect affect is more effective than direct effect.

In the TAM model, the attitudes of the two hypotheses (H13, $\beta = 0.458$, $\rho < 0.001$; H14, $\beta = 0.429$, $\rho < 0.001$) are shown as direct effects. The perceived usefulness and perceived ease of use demonstrate effects on the user's attitude. But H15 ($\beta = -0.028$) demonstrates that perceived ease of use has no effect on perceived usefulness. This proves that in the use of science education tools, this factor has no significant effect on perceived usefulness, H16 ($\beta = 0.518$, $\rho < 0.001$). Intention to use is also supported by the significant path. Among these, perceived ease of use indirectly affects intention to use. Although the effect of perceived ease of use on perceived usefulness is not significant, it does have a more significant effect on attitude. Thus, we can see that perceived ease of use still has a positive effect on intentions.

Overall, all constructs will have positive direct or indirect effects on intention to use, Except for computer self-efficacy, which has a negative impact. Regarding tools for science education, attitude has the greatest contribution (total effect) on intention to use the tool.

5 Discussions and conclusion

Current reports indicate scientific technology application is springing up (Ahmadian and Azizi 2011; Abd-Alla et al. 2011; Chen 2004, 2006a, b, 2007a, b, c 2008a, b, c, 2009a, b, c, d, e, f, g, 2010a, b, c, d, e, f, g, h, 2011a, b, c, d, e, f, g, h, i, j, 2012a, b, c, d, e, f, g, h, i, j). Using Lego NXT to assist in teaching has become a prominent practice in science education. This study proposes a research model based on SCT, ECM, and TCM which are used to discuss key factors of users' perceived usefulness, satisfaction, attitude, and intention to use in scientific literacy. The resulting data show the theory's validity for each construct and connection, as shown in Fig. 5.

The construct had an R^2 of 78.1 % for perceived usefulness, 80 % for satisfaction, 67.8 % for attitude, and 78.7 % for intention to use Lego NXT. These paths demonstrate that when combined, these models are capable of providing a high proportion of hypothesized impact of dependent variation. The perceived usefulness construct connects all factor models, like computer self-efficacy, system functionality, content features, interaction, confirmation, and perceived ease of use. The impact of satisfaction on confirmation and cognitive factors also showed good predictive ability. There are not many factors that can influence attitudes, but are also powerful enough to impact intention to use. In addition, the estimation of intention to use path receives support from perceived usefulness, satisfaction, and attitude.

The path is significant as shown by the R^2 result, which increases our confidence in the model testing results, and supports the idea that Lego NXT is useful for science education and scientific literacy. The research results indicate that perceived usefulness, satisfaction, attitude, and intention to use are strong factors influencing Lego NXT's use in science education. From the social cognitive perspective, the effect of environment (system functionality, content features, interaction, and learning climate) on the intent to use Lego NXT is indirect. The environment does not directly affect the occurrence of learning, but the cognitive (perceived usefulness and computer self-efficacy) aspect has a direct affect on individual behavior. In this study, it is demonstrated that computer self-efficacy does not have a major effect on perceived usefulness.

This theory does not conflict with Bandura (1986)'s proposition of the interplay between cognitive factors, environment, and reciprocal behavior. Computer self-efficacy is not a major factor affecting the willingness to use Lego. Computer self-efficacy is related to the experience (Wilfong 2006; Ballantine et al. 2007; Madhavan and Phillips 2010), while Lego NXT experience and proficiency affect perceived usefulness. If there is good exercise or training through the teaching courses, it will enhance perceived usefulness (Hasan 2006; Tang and Austin 2009).

The ECM indicates that confirmation has an indirect effect on intention to use Lego NXT whether or not the expectations a user holds before using Lego NXT has a significant effect on perceived usefulness (Oliver 1980). Users have certain expectations prior to using scientific tools; based on this feature, the development of scientific literacy should focus on scientific tools that are easier to use well.

In the TCM, attitude has a direct affect on intention to use Lego NXT. This hypothesis has been confirmed in many papers (Liu et al. 2009; Gagnon et al. 2011).

There are some factors in this theory related to perceived usefulness and perceived ease of use. Perceived usefulness has been mentioned earlier, so at this point the focus is on perceived ease of use. In this study, the perceived ease of use is not significant; it does not affect utilization intention of Lego, but it does influence perceived usefulness. Computer self-efficacy is a key factor affecting perceived usefulness for both experienced and inexperienced affected users (Yu et al. 2005; Ha and Stoel 2009). The participants in this study have experience using Lego NXT. It can therefore be concluded that those who are unskilled may have doubts about the perceived usefulness. They have a higher rate of intention to use Lego NXT. This means that the perceived ease of use is not a determining factor to perceived usefulness. New technologies may be unfamiliar processes to users. In this case perceived ease of use has more influence on perceived usefulness (Escobar-Rodriguez and Monge-Lozano 2012). Taylor and Todd (1995) mentioned that when users gain more experience, they may overcome ease of use and hold a better attitude toward perceived usefulness.

Further analysis on the age of the participants in relation to the study of computer self-efficacy and perceived ease of use is carried out. It can be seen that better result was shown for the ages 13–25, showing better results for these two factors (see Table 6). The table shows that the previous group (6–12) has less experience using scientific tools, while the older group (13–25) has more related experienced. So for them, there is a more significant effect for computer self-efficacy and perceived ease of use.

The last factor is intention to use. Social cognitive and scientific models directly or indirectly affect the full description of the factors. It is also confirmed that Lego NXT is indeed an effective tool for science education that can assist in users' learning, furthering science education, and supporting scientific literacy. In this study, we found that the cultivation of scientific literacy is not only about enhancing scientific capacity but providing an effective environment for learning and interaction is also very important. Meeting the expectations of students, effective attitude and satisfaction are the key factors for developing scientific literacy. This study found that even though the tools' ease of use and users' computer self-efficacy have no significant effect, they are still difficult to resist for users interested in learning. Therefore, carefully choosing a good tool is very important, and Lego NXT meets the needs of the user.

Scientific literacy can be improved though scientific education, along with developing the ability to think about important questions, explains phenomena, uses scientific evidence, and so on. Together with better course content and teaching tools, it can be made

Table 6 Two factors distinguishing the age of the coefficient

Age	Computer self-efficacy	Perceived ease of use	Number	Percent
Before block	0.008	−0.082	89	52
After block	0.037	0.004	83	48

more effective. We want students to develop scientific literacy skills, face a variety of global environment and social changes, and cultivate their abilities to explain and confirm must be much better. This is a subject that future studies in this area.

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Appendix: Factor structure matrix of loadings and cross-loadings

Scale Items	CSE	SF	CF	INT	PU	LC	SAT	CON	ITU	ATT	PEU
CSE1	**0.7581**	0.6306	0.495	0.4227	0.5674	0.4803	0.5162	0.569	0.5094	0.4195	0.6103
CSE2	**0.852**	0.5762	0.6843	0.618	0.6003	0.6861	0.7126	0.6671	0.6898	0.7205	0.6495
CSE3	**0.8072**	0.5365	0.5742	0.5821	0.4919	0.6263	0.5534	0.6123	0.5744	0.6218	0.567
SF1	0.6365	**0.9096**	0.6159	0.6062	0.7581	0.6763	0.6854	0.7488	0.6521	0.6687	0.6787
SF2	0.6817	**0.9151**	0.6724	0.7209	0.7462	0.6674	0.6856	0.6683	0.6352	0.6788	0.694
CF1	0.5843	0.6141	**0.8308**	0.6006	0.6663	0.6689	0.6466	0.6389	0.6428	0.5783	0.7081
CF2	0.6356	0.648	**0.8908**	0.7103	0.7168	0.7379	0.7659	0.7231	0.7708	0.7193	0.6353
CF3	0.6311	0.5212	**0.8142**	0.6169	0.5963	0.7343	0.7076	0.7031	0.7202	0.7166	0.6019
INT1	0.5475	0.6225	0.6203	**0.866**	0.6231	0.639	0.6516	0.597	0.6191	0.6967	0.586
INT2	0.6348	0.6659	0.7223	**0.905**	0.7159	0.7548	0.74	0.6927	0.7163	0.7184	0.673
PU1	0.5568	0.692	0.6324	0.6124	**0.858**	0.6612	0.6983	0.6721	0.6305	0.6101	0.5767
PU2	0.5624	0.7481	0.6296	0.6972	**0.8435**	0.68	0.7161	0.7281	0.6931	0.7253	0.6506
PU3	0.6348	0.6835	0.7874	0.6476	**0.8553**	0.7165	0.7624	0.7216	0.7215	0.6862	0.6542
PU4	0.5986	0.6844	0.6099	0.6249	**0.8536**	0.7063	0.6732	0.6024	0.5867	0.5875	0.5845
LC1	0.6468	0.5878	0.6959	0.7277	0.665	**0.8613**	0.701	0.6924	0.7193	0.7925	0.6433
LC2	0.6208	0.6319	0.7401	0.6416	0.7192	**0.8705**	0.7057	0.6962	0.7234	0.7105	0.6512
LC3	0.6637	0.699	0.7583	0.6894	0.73	**0.8752**	0.7433	0.7339	0.7194	0.7237	0.7294
SAT1	0.6124	0.5809	0.689	0.6352	0.6397	0.6513	**0.8201**	0.6864	0.6989	0.7234	0.6046
SAT2	0.6461	0.6913	0.6306	0.7004	0.7681	0.681	**0.8254**	0.7027	0.646	0.6776	0.6523
SAT3	0.5195	0.4662	0.669	0.6117	0.6024	0.6658	**0.8087**	0.6514	0.6505	0.6614	0.5786
SAT4	0.6639	0.7271	0.7651	0.6551	0.7483	0.7243	**0.8482**	0.7364	0.7374	0.6841	0.6945
CON1	0.7066	0.6388	0.7002	0.6626	0.6816	0.7305	0.725	**0.8849**	0.7582	0.8165	0.6742
CON2	0.6293	0.6808	0.7123	0.6332	0.6696	0.7232	0.7656	**0.8818**	0.7208	0.7312	0.6803
CON3	0.6565	0.6991	0.7013	0.6074	0.7361	0.6662	0.7003	**0.8361**	0.6758	0.6524	0.6825
ITU1	0.5986	0.6186	0.7123	0.6703	0.7009	0.7255	0.7151	0.7364	**0.8921**	0.7824	0.6546
ITU2	0.6836	0.5732	0.7452	0.6757	0.658	0.7518	0.7538	0.7289	**0.8947**	0.7656	0.6751
ITU3	0.6571	0.6365	0.7988	0.6821	0.6879	0.7401	0.7497	0.7465	**0.861**	0.7855	0.6697
ITU4	0.6078	0.6166	0.6415	0.5838	0.634	0.6453	0.6408	0.6451	**0.8091**	0.6259	0.5441
ATT1	0.6241	0.6191	0.7122	0.7005	0.7008	0.7524	0.7374	0.7666	0.7984	**0.8936**	0.6802
ATT2	0.661	0.6744	0.6952	0.7311	0.6863	0.7837	0.7685	0.7449	0.7892	**0.9153**	0.6683
ATT3	0.6716	0.6885	0.7137	0.7094	0.6728	0.7555	0.7218	0.7531	0.7134	**0.8709**	0.6922
PEU1	0.5573	0.5904	0.6276	0.6056	0.5904	0.6017	0.6152	0.643	0.6191	0.5988	**0.8187**

Appendix continued

Scale Items	CSE	SF	CF	INT	PU	LC	SAT	CON	ITU	ATT	PEU
PEU2	0.5888	0.6071	0.5762	0.5403	0.5516	0.5689	0.6165	0.6014	0.555	0.5536	**0.8181**
PEU3	0.7166	0.6416	0.6513	0.5676	0.5924	0.6784	0.6302	0.6094	0.6027	0.6308	**0.8399**
PEU4	0.6887	0.6938	0.7208	0.6817	0.6992	0.7536	0.721	0.77	0.7019	0.7612	**0.8968**

CSE computer self-efficacy, *SF* system functionality, *CF* content features, *INT* interaction, *PU* perceived usefulness, *LC* learning climate, *SAT* satisfaction, *COM* confirmation, *ITU* intention to use, *ATT* attitude, *PEU* perceived ease of use

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