ROUTLEDGE INTERNATIONAL HANDBOOK OF SCHOOLS AND SCHOOLING IN ASIA

Edited by Kerry J. Kennedy and John Chi-Kin Lee

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CURRENT STATUS, CHALLENGES, AND OPPORTUNITIES OF THE INTELLIGENT TUTORING SYSTEM (ITS) IN DEVELOPING COUNTRIES IN ASIA

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Introduction

Currently, education systems in the Asian region are undergoing extraordinary developments: a growing number of people are gaining access to formal and informal learning, curricula are diversifying, and educational institutions are experimenting with new and innovative forms of delivery (Asian Development Bank, 2011). Despite this, Asian educational systems continue to confront four overarching challenges – namely, maintaining education quality, improving the relevance of curricula, improving on expenditure of financial resources, and balancing expansion with greater equity. One technological solution that has the potential to offer quality instruction to many students is the Intelligent Tutoring System (ITS).

In recent years, an increasing number of researchers have shown interest in the development and/or deployment of ITSs for and in developing countries.[1] In particular, ITSs are seen to have the potential to augment or support overstretched educational systems (Nye, 2015), thereby becoming instruments of equity, quality, and efficiency.

This chapter provides an overview of ITS-related research undertaken in Asian developing countries. The chapter begins with a brief overview of the development and nature of ITSs. It then outlines the methods for selecting and analyzing the literature used for the study, describing the research foci of these studies and highlighting the findings in relation to the effectiveness of ITSs developed or deployed in these countries. The chapter concludes with a discussion of the limitations of current ITS research and identifies potential areas for further study.

A brief overview of Intelligent Tutoring systems

The evolution of ITSs follows developments in computer technology and cognitive psychology. According to Shute and Psotka (1994), the first time computerized technology was

used as a teaching aid was in 1926. This machine administered multiple-choice questions to students and provided immediate feedback on their responses. However, this technology was not underpinned by a learning theory; it simply presented a series of questions. The mid-1950s saw the rise of computers that had a greater capacity for logical decision-making and for data storage and manipulation. Around the same time, the educational psychology literature asserted that people tend to learn most effectively through individualized tutoring, and computers were considered to be the most appropriate vehicle to carry out this type of instruction. Computer-based programmed instruction (PI) emerged in the 1960s in which students were taken through problem-solving activities in a lock-step fashion. This was followed by computer-assisted instruction (CAI) based on insights from behaviorist stimulus-response psychology. CAI differed from PI in that it had the capacity to branch out into specific content or remediation appropriate to the students' progress. Intelligent CAI (ICAI) improved upon these branching capabilities by classifying and diagnosing student errors in order to be able to address misconceptions with greater specificity. Later on, the education and artificial intelligence disciplines began to collaborate to develop more efficient methods to store and retrieve knowledge, to reason using induction and deduction, and to communicate with students. These investigations gave rise to ITSs.

An ITS is a computer-based learning tool that makes use of artificial intelligence to create educational environments that respond both to the learner's level and needs and to the instructional agenda (Graesser, Conley, & Olney, 2012). The ITS provides learners with personalized hints, guidance, remediation, and emotional support in order to achieve a learning goal.

In Shute and Psotka's (1994) analysis, ITSs must be able to diagnose students' knowledge using principles rather than pre-programmed logic and to decide on what it should teach the student next. Thus, ITS architecture can be divided into four major components: a domain or expert model, a learner or student model, a tutor or pedagogical model, and a user interface. The domain model contains a representation of the content (skills, knowledge, procedures, and so on) that the student is required to learn. It also includes information pertaining to common student errors and misconceptions so that ITSs are able to provide appropriate assistance when such errors or misconceptions occur (Sottilare, Graesser, Hu, & Holden, 2013).

The learner model contains the psychological states of learners (Sottilare et al., 2013). While in the 1970s and 1980s ITSs tended to track students' knowledge and skills (Shute & Psotka, 1994), over the last two decades there has been a growing interest in tracking non-cognitive states, such as student emotion and motivation (Damasio, 2000; Picard, 1997).

The tutor model is responsible for regulating the interactions between the student and the system (Ahuja & Sille, 2013). Informed by both the domain model and the learner model, the tutor model selects teaching strategies that will most effectively assist the learner's progress (Sottilare et al., 2013). In Cheng, Zhao, Xu, and Li (2014), with the Personalized Mathematics ITS, for example, each student begins by taking a diagnostic test which establishes his or her prior knowledge. The tutor model then suggests lesson preparation based on the results of the diagnostic.

Finally, the user interface draws input from the learner and conveys this information to the different models (Sottilare et al., 2013). The interface also receives output from the tutor model and displays it to the learner in a form that the learner can understand. An interesting example of the user interface is Scooter the Tutor, an animated dog that is part of the Scatterplot Tutor described in Rodrigo et al. (2012). Scooter detects a form of non-learning behavior called "gaming the system", which refers to student abuse or misuse of the tutoring system in order to progress through the material without actually learning and which usually manifests as systematic guessing or repeated hit requests (Baker et al., 2006). When the student uses the tutor

properly, the user interface displays a happy version of Scooter, i.e., Scooter giving a thumbs–up or wagging his tail. However, if the student games the system, Scooter turns red and appears angry.

The ability of these systems to adapt to learner needs has had a positive impact on their effectiveness as carriers of educational content. A recent meta–analysis by Ma et al. (2014) found that students using ITSs tended to out-perform those provided with teacher-led, large-group instruction; non–ITS computer-based instruction; and traditional learning materials, such as textbooks. The only educational delivery mechanism that matched ITSs' effectiveness was one-on-one or small-group human tutoring. Further research findings relating to the effectiveness of ITSs are also described.

Data collection and analysis

In order to identify relevant studies on ITS for inclusion in the analysis for this chapter, we conducted searches of various citation databases (Scopus, Web of Science, ERIC, Google Scholar, and PsycINFO) using a combination of keywords, such as *intelligent tutoring systems*, *achievement*, *effectiveness*, *outcome*, and *learning*. We also conducted Internet searches of conference proceedings. The initial screening yielded 40 abstracts published between 2010 and 2015 that were related to ITS based on their research foci. The research foci fell into two groups. The first group comprised theoretical papers which focused on the ways in which ITSs should be designed, work, or behave, while the second group included studies relating to ITS development in terms of actual programming. The task of screening all the abstracts generated by the search in order to identify their relevance to the study was completed independently by two of the authors of this chapter. The overall inter-reliability was 0.75, which is considered to be an acceptable result.

Geography and foci of ITS research in Asia

The papers surveyed originated from China, Hong Kong, Indonesia, Malaysia, Pakistan, Palestine, Philippines, Taiwan, Turkey, and Thailand. As highlighted earlier, the research foci ranged from theoretical contributions to ITS implementations and deployments. Table 36.1 summarizes the studies that were examined.

Table 36.1 Included studies and their research foci

Authors	Country	Subject area	Research foci
Cheng et al., 2014	China	Mathematics	Development
Chung, Nagai, & Rodrigo, 2013	Philippines	Japanese	Development
Hwang, Tseng, & Hwang, 2008	Taiwan	Mathematics	Development
Kazi, Haddawy, & Suebnukarn, 2010	Thailand and Pakistan	Medicine	Development
Li et al., 2010	China	Science	Development
Phobun & Vicheanpanya, 2010	Thailand	Not applicable	Theory-oriented
Regalado et al., 2015	Philippines	Filipino	Development
Rodrigo et al., 2012	Philippines with US collaborator	Mathematics	Theory-oriented
San Pedro, Baker, & Rodrigo, 2014	Philippines and US	Mathematics	Theory-oriented
Sun, Li, & Xia, 2013	China	Not applicable	Theory-oriented

The papers we classified as "theory-oriented" focus on the foundational concepts that can be used as bases for designing or building an ITS. As such, they either attempt to explain ITS architecture or propose augmentations or improvements but do not address issues of implementation. Some of these studies make use of existing systems. However, rather than discussing the processes by which these ITSs were built, they use these systems as data-gathering instruments. The analysis of the data reveals insights that are then used to inform learner, pedagogical, or domain model design or user interface implementation.

By way of example, Phobun and Vicheanpanya (2010) describe the architecture and flow of an adaptive intelligent tutoring system (AITS). The authors combine the features of an ITS with those of adaptive hypermedia. Adaptive hypermedia shares some of the characteristics of ITSs insofar as content and navigation options are adapted based on learner goals and knowledge. The authors distinguish between the two types of systems based on applicability, where adaptive hypermedia seems best suited for teaching declarative knowledge, while ITS is more appropriate for problem-solving. The AITS proposed by Phobun and Vicheanpanya includes a system that walks the learner through a problem-solving process while he or she is learning materials usually found in ancillary documents, such as textbooks, and takes the form of adaptive hypermedia. One interesting detail about the architecture of the AITS is that the authors recommend the expert model, rather than the teaching or pedagogical model, to compare the domain knowledge against the knowledge of the learner. Having identified the learner's knowledge deficits, the expert model presents the learner with a list of recommended content.

Some theoretical papers describe how one or more of the models within the ITS architecture can be expanded to include new capabilities and features. The work of Sun et al. (2013) attempts to address ITSs' lack of emotion and how this shortcoming might undermine learners' motivation and learning. They describe how emotion recognition can be built into these systems. They begin by taking a picture of the student while the student's face has a neutral expression. A camera trained on the student's face then feeds facial expression data to the ITS. The ITS compares the facial expression data with the neutral expression and analyzes whether the student is expressing a positive or negative affective state. If the ITS determines that the student is distressed, it can search for hints that fit the problem that the student is currently trying to solve. The expert model of the ITS can then tag lessons with an emotional difficulty rating, depending on how students fare.

Several studies conducted in Asia made use of existing ITSs as a test bed for experiments, rather than as a regular part of the school curriculum. Researchers responsible for these experiments were usually investigating student-related phenomena, such as learning gains, preferences, behaviors, or affective states. Studies of this type contribute to ITS research in that they lead to more sensitive and nuanced student models.

A study by Rodrigo et al. (2012) used an ITS developed in the United States to investigate the effects of Scooter the Tutor, an embodied conversational agent (ECA), on the behavior and affective states of students in the Philippines. In prior studies conducted in the United States, Scooter was shown to discourage student off-task behaviors. However, this finding was not replicated in the Philippine study. Indeed, while US students disliked the ECA, students in the Philippines thought of the ECA as useful, helpful, and caring. The findings from the Rodrigo et al. study suggest that perceptions of the same ECA are culturally influenced and that design decisions should be informed by ethnographic studies of target populations.

Using the same data set, San Pedro et al. (2014) studied the relationship between affect and student carelessness, which is defined as student failure to provide a correct answer on a

question whose skill the student has already mastered. They found that carelessness was common among students who were highly engaged and less common among students who were confused and bored. This did not indicate that engaged students committed fewer errors; rather, it meant that their errors, when committed, were likely to be careless, most probably attributable to overconfidence. Students who were bored or confused, in contrast, tended to make honest errors, i.e., errors that stemmed from a genuine lack of knowledge.

ITS development

Much of the ITS literature from Asia focuses on the development of ITSs across various domains. Papers often discuss the architecture of the ITS, emphasizing reinterpretations or departures from the classic modules.

Salinlahi (Regalado et al., 2015) is an ITS that teaches Filipino grammar and sentence construction. It offers students two types of exercises: translation and creation. Salinlahi's developers describe its architecture in terms of the user-interface, expert, tutoring, and student models, which were highlighted earlier. The user interface is responsible for interactions between the student and the system. The expert model contains two analyzers, one for each type of exercise: the translation analyzer, which cross-checks the student's response against the expected answer, and the creation analyzer, which parses student input and determines its distance from a preferred response. The student model represents that which the student has and has not mastered. Finally, the tutoring model tracks student attempts, collaborates with the expert model regarding student assessment, and updates the student model.

Chung et al.'s (2013) ITS also focuses on language but with a more limited scope, namely the teaching of Japanese language particles. The paper discusses the student model as an overlay of the expert model, but does not provide information on how the domain knowledge is structured. Chung et al.'s paper places emphasis on the design of the user interfaces, rationalizing design choices using the cognitive theory of multimedia learning (Mayer, 2005). The principles that the authors employ include the focus on task-relevant information, the limitation of unnecessary information, and the guiding of student attention.

The systems of Regalado et al. (2015) and Chung et al. (2013) tend to follow classic ITS architecture. Other researchers innovate with their systems' underlying structures.

For instance, Kazi et al. (2010) describe Medical Tutor Employing Ontology for Robustness (METEOR), an ITS for problem-based learning in medicine. METEOR is built on top of the Unified Medical Language System (UMLS), a knowledge base containing over 2 million medical concepts. These concepts and their causal relationships are codified based on human domain experts. A solution to a problem-based scenario usually adds causal links to the knowledge base and requires about 3 to 4 hours to code. Instead of building a separate student model, the authors propose using the expert knowledge base to assess directly student solutions for partial correctness and to generate hints. Evaluations of the resulting system show that METEOR's hints were sometimes better than those of typical problem-based learning tutors. Furthermore, the approach of bypassing the student model saved time and effort when expanding the ITS.

Li et al. (2010) developed a science workbench that enabled students to conduct virtual experiments regarding light and reflection. In the periscope experiment, for instance, students must position mirrors so that the images in view of one end of the periscope become visible to the eye at the other end. The learning environment is a network-based system of multiple agents that share resources and coordinate to achieve common ends. Following the client-server architecture, students interact with a teacher and student agent on the client side. The

teacher agent is responsible for the tracking and analysis of student characters as well as the selection of teaching strategies. The student agent manages interactions between the student experiment system and the rest of the ITS. A database server houses data regarding student character, experiment teaching strategies, experiment processes, teaching resources, and laboratory apparatuses. A collaboration server manages communications among the various agents.

The study by Hwang et al. (2008) contains an extensive discussion of how questions map to specific mathematical concepts, such as coefficients, exponents, and polynomial arithmetic. The representation also contains information regarding the interdependencies among concepts. When evaluating student performance, the software is able to identify which lessons the system needs to provide to the student and in what sequence. An example of this is if a student fails to meet the mastery criteria of both the exponent and distributive law concepts, the system must then enhance the student's "exponent->multiplication of polynomial" learning path and the "distributive law->multiplication of polynomial" learning path.

Finally, Cheng et al. (2014) discuss a mathematics ITS (MITS) that they developed in response to the need for mathematical content in Chinese. The MITS provides learners with personalized support in the form of online courses with mathematics-related web pages and videos. MITS is also able to respond to student inquiries and clarifications with extensive tutoring information. MITS is organized as a client-server system with three layers: expression, function, and data. The client is the expression layer − the equivalent of the user interface model in classic ITS architecture; the function layer refers to the machine intelligence that provides the rationale for the ITS's next actions; and the database layer contains course content and user data. As with the system of Hwang et al. (2008), the mathematics content of MITS is organized as both units of concepts and the relationships among them. The learner model tracks the student's mastery of each unit and then recommends the next lessons accordingly.

Learning effectiveness of ITS: a meta-analysis of selected Asian research

When ITSs are deployed to influence student achievement, results tend to compare favorably against other teaching tools and methods. To the best of our knowledge, only two meta-analysis studies about the learning effectiveness of ITS have been published thus far. Steenbergen-Hu and Cooper (2013) conducted a meta-analysis on the effectiveness of ITS in mathematics learning on K–12 students. They found that, overall, there was a very small positive effect on K–12 students' mathematical learning compared to the traditional mode of teaching. Ma, Adesope, Nesbit, & Liu (2014) conducted a meta-analysis to compare the learning outcomes of the learners between ITS and non-ITS learning modes. They found a positive effect of ITS-based learning, with an effect size ($g = +0.41$). Although these two studies have produced empirical evidence of the effectiveness of ITS, the samples also contain data from Western countries. Therefore, in this section, we present the results of our meta-analysis on the learning effectiveness of ITS in Asia specifically, based on a selection of relevant studies identified during the literature search.

Inclusion criteria

The papers included in the meta-analysis were selected on the basis of a number of criteria, namely that they reported on original data; that samples were taken from Asia; that they compared learning outcomes from ITS learning environments with those from a non-ITS learning environment; and that sufficient quantitative data was presented in order to calculate effect sizes

(articles in which the sample size for each group was not cited were excluded). Based on these criteria, a total of 12 studies qualified for our meta-analysis (see Appendix 1). While our sample size might seem limited, Pigott (2012) contends that a minimum of two studies is sufficient to conduct a meta-analysis of this kind.

Coding of study features

In order to identify the substantive features that might contribute to the variation, the selected studies needed to be coded. The substantive features were coded according to the following categories:

*   Grade level: Elementary School (1–6), Junior High School (6–9), High School (10–12), or Undergraduate
*   Types of Asian country: Developed or Developing
*   Subject domains: Mathematics, Earth Science, Computer Programming, or Others

Calculation and analysis of effect sizes

Borenstein, Hedges, Higgins, and Rothstein (2009) recommend the following steps to conduct a meta-analysis: (1) calculate the effect sizes for each article, (2) calculate the weighted mean effect size across articles, (3) determine the confidence interval for the average effect size, and (4) undertake a heterogeneity test analysis (QB).

After calculating the individual effect size for all 12 studies, comprehensive meta-analysis software was employed to calculate the unbiased effect size (Hedge's g), as well as the values for the test of heterogeneity (QB). In the present study, we calculated only one effect size for each article. In those cases where the studies had multiple effect sizes, these were integrated into one effect size (following Borenstein et al., 2009). Appendix 1 shows the coded information and effect sizes of the selected 12 studies.

Results

OVERALL EFFECTS

As indicated in Table 36.2, the overall weighted effect size is +0.570, with a 95% confidence interval of 0.114–1.026. Q statistics show that the effect sizes in the meta-analysis were heterogeneous ($Q = 113.6$, $df = 11$, $p < 0.00$), which indicates that there are differences among the

Table 36.2 Overall effect sizes

	k	ES	SE	Variance	95% confidence interval		Test of mean		Test of heterogeneity in effect sizes		
					Lower	*Upper*	*Z*	*P*	*Q-value*	*df(Q)*	*p*
Fixed	12	0.229	0.066	0.004	0.1	0.359	3.474	0.001	113.6	11	0.000
Random	12	0.570	0.233	0.054	0.114	1.026	2.447	0.014			

Effect sizes of learning achievement for moderator variables

effect sizes resulting from factors other than simple sampling error. Therefore, a random effects model was reported (Borenstein et al., 2009). In order to explain this variance, substantive features (e.g., type of Asian country, grade level, subject domain) were used to model some of the variation.

GRADE LEVEL

Table 36.2 indicates that junior high school students had a high effect size on learning achievement ($g = 1.684$, z = 5.996, $p < .05$), while elementary school students ($g = -0.217$, z= -1.968, $p < .05$) had a small effect size. High school ($g = 0.129$, z = 0.63, $p > .05$) and undergraduate ($g = 1.031$, z = 1.598, $p > .05$) students did not show any significant effect sizes. The *QB* achieved significance ($QB = 52.10$, $p < .05$), indicating that the mean effect size differs significantly between the categories.

TYPES OF ASIAN COUNTRY

Table 36.2 indicates that developing countries in Asia had a high effect size on learning achievement ($g = 1.223$, z = 3.685, $p < .05$), while developed countries did not show any significant effect size ($g = -0.099$, z = -0.507, $p > .05$). The *QB* achieved significance ($QB = 11.77$, $p < .05$), indicating that the mean effect size differs significantly between the categories.

SUBJECT DOMAINS

Table 36.3 indicates that other subjects had a high effect size on learning achievement ($g = 1.562$, z = 2.599, $p < .05$), while mathematics ($g = 0.561$, z = 1.515, $p > .05$),

Table 36.3 The learning-achievement effect sizes of categories and their related moderator variables

Category	k	G	Z	95% CI	QB
Grade level					52.10*
1. Elementary school	1	−0.217	−1.968★	[−0.434,−0.001]	
2. Junior high school	1	1.684	5.996★	[1.133,2.234]	
3. High school	5	0.129	0.63	[−0.273,0.532]	
4. Undergraduate	4	1.031	1.598	[−0.230,2.255]	
Types of Asian country					11.77*
1. Developed country	6	−0.099	−0.507	[−0.483,0.284]	
2. Developing country	6	1.223	3.685★	[0.572,1.873]	
Subject domains					6.725*
1. Mathematics	4	0.561	1.515	[−0.615,1.287]	
2. Computer programming	4	0.401	0.860	[−0.513,1.314]	
3. Earth science	2	−0.204	−0.566	[−0.912,0.503]	
4. Others	2	1.562	2.599★	[0.384,2.740]	

*$p < .05$

Note: Regalado et al. (2015) do not mention grade level. Therefore, for grade level, the total number of studies is 11.

computer programming ($g = -0.401$, z = -0.860, $p > .05$), and earth science ($g = -0.204$, z = -0.566, $p > .05$) did not show any significant effect size. The *QB* achieved significance (*QB* = 7.76, $p < .05$), indicating that the mean effect size differs significantly between the categories.

Analysis of empirical research from Asia on the learning effectiveness of ITS has revealed that the overall effect of ITS is better than both the traditional mode of learning or not using ITS as an intervention, with a moderate effect size of 0.570. Through the analysis of moderator variables, we found that ITS has been applied to various grade levels, types of Asian country, and subject domains. The effect of such usage was greater for developing countries than for developed countries in Asia, and the usage for junior high school students was more effective than for elementary, high school, and undergraduate students. The novelty effect may be the reason for better performance of ITS in developing countries than in developed countries. Chien, Chang, and Chang (2016) reported that new technology usually receives greater attention from students when it is incorporated into the classroom. As a result, there are positive gains in learning achievement owing to an increase in attention.

Limitations of ITS research in Asia

Several observations can be made based on our review of the literature. On a positive note, within Asia, there is a research community that is interested in contributing to the theoretical foundations, construction, and deployment of ITSs. When deployed, ITSs are effective carriers of educational content. Tools such as these are needed in the Asian region in general and in developing countries in particular.

However, Asian ITS research exhibits a number of limitations, such as the following:

- The research tends to be compartmentalized, i.e., studies tend to focus on only one aspect – ITS theory, development, or implementation – rather than on the entire lifecycle from conceptualization to classroom use. As such, the Asian region seems to lack end-to-end solutions where theory, implementation, deployment, and evaluation form a virtuous cycle.
- Many contributions to theory do not address implementation.
- ITSs that are developed locally are tested in laboratories rather than schools.
- ITSs that are used in schools tend to be developed in other countries and only for a limited time as part of formal experiments.
- Finally, our review did not yield any evidence of the integration of ITSs as part of the regular school curriculum.

What are the possible reasons for these limitations to the research? To begin with, there are instances in which ITSs require Internet connectivity and relatively high computer hardware specifications. However, despite the growing availability of computers and the Internet, many schools in developing countries still lack infrastructure – electricity, telecommunications, and computer hardware (Nye, 2015) – to support these applications. Some Asian countries have outperformed international standards of technology-assisted instruction. Nevertheless, the lack of infrastructure in other countries prevents them from benefiting from these resources. In-country differences are also stark: while urban areas adopt technology quickly, remote areas do not (UNESCO Institute of Statistics, 2014).

Related to the lack of infrastructure is the paucity of culturally appropriate content (Nye, 2015). The examples in this paper notwithstanding, ITSs tend to be built in Western, industrialized, educated, rich, and developed countries (Blanchard, 2012). Hence, the language and culture (symbols, contexts, situations, and motivations) of the ITSs may not be a good fit for the target country's students.

Another major impediment is students' lack of technology skills. In schools with few computing facilities, students receive limited opportunities to work with the machines on a one-to-one basis. Furthermore, they almost never use learning software, such as ITSs (Rodrigo et al., 2014). When new computer-based educational interventions are introduced, students typically need support – at first to become comfortable with the technology and then to start benefiting from it.

Opportunities for further research

The results of our study have several implications for educators and policy-makers in developing countries. The gaps and barriers open many opportunities both for the generation of new knowledge and for greater societal impact. Within the Asian region, in particular, continuing research, development, deployment, and evaluation of ITSs has the potential to promote greater educational quality, equity, and efficiency.

For example, there is a need to develop ITSs beyond universal subject areas such as mathematics and science. Subject areas that have a more localized interest (e.g., local languages and local histories) are ripe for technology interventions. ITSs can be used to preserve and promote local culture – both tangible (art, crafts, and historical sites) and intangible (social values, customs, and religious beliefs) (Mortara et al., 2014).

ITSs could also be designed for deployment on mobile phones and tablets – technologies that are far more ubiquitous than personal computers. However, as highlighted earlier, although Internet accessibility is increasing, many parts of Asia still lack electrical and telecommunications infrastructure (Nye, 2015; UNESCO Institute of Statistics, 2014). It would therefore be beneficial if ITSs were designed for stand-alone use. If deployed on handheld devices, ITSs should attempt to maximize battery life by being graphics-light and by minimizing the use of device components such as the camera, GPS, and accelerometer.

ITSs that already exist, and which have been proven to be effective in laboratory studies or in other countries, could be deployed on a wider scale. This may require translation to the local language as well as the localization of content. Imagery and symbolisms (e.g., fruits, vegetables, animals, and sports) would need to be relevant to the target audience.

The effects of deployed ITSs could be monitored and studied. Aside from tracking learning, researchers should be particularly mindful of ITSs with affective interventions, as students from different cultures respond to these interventions in different ways. The findings of Rodrigo et al. (2012), for example, showed that Philippine students regarded Scooter the Tutor very differently from their US counterparts. Culture influences how people regard authority, how individualistic or collective their thinking is, the degree to which they have to maintain smooth interpersonal relationships, and so on. These variations interact with affective interventions to produce different effects.

Finally, investigations of ITS deployments present opportunities for collaboration between researchers from different countries. Collaborations can lead to the transfer of technology from more- to less-developed countries, which, in turn, can lead to more universally applicable ITSs and increase access to quality instruction. International collaborations can also contribute to the development of ITSs that are more culturally sensitive.

Appendix 1
CODED INFORMATION OF SELECTED STUDIES FOR META-ANALYSIS

Study	Sample size	Effect size	Grade level	Subject domains	Type of Asian country
Abu–Naser (2009)	62	0.686	Undergraduate	Computer Programming	Developing
Bulut Özek, Akpolat, and Orhan (2013)	108	1.907	Undergraduate	Computer Programming	Developing
Chen (2008)	220	−0.217	Elementary	Mathematics	Developed
Chen (2011)	145	−0.616	Undergraduate	Computer Programming	Developed
Chien, Yunus, Suraya, Ali, and Bakar (2008)	62	1.684	Junior high school	Mathematics	Developing
Huang, Yeh, Li, and Chang (2010)	72	−0.003	High school	Earth Science	Developed
Hwang, Tseng, and Hwang (2008)	76	0.746	High school	Mathematics	Developed
Keun–Woo, EunKyoung, and YoungJun (2010)	115	−0.222	High school	Computer Programming	Developed
Regalado et al. (2015)	27	1.011	Not available	Others	Developing
Rodrigo et al. (2012)	126	0.159	High school	Mathematics	Developing
Wang, Rosé, and Chang (2011)		−0.264	High school	Earth Science	Developed
Yang, Leung, Yue, and Deng (2013)	52	2.217	Undergraduate	Others	Developing

Acknowledgements

Note

1 Countries are classified as "developing" or "developed" based on their gross national income (GNI). Developing countries are those with GNIs of less than US$12,746 (World Bank, 2015).

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