Afterword

Different authors come from different research and development environments as well as different interest groups. Evaluating this unique mixture of contributors’, personal view on the future and new directions on intelligent tutoring system design, implementation and evaluation is presented in this section. The future of intelligent tutoring system will depend on innovative academic and industrial contributions to this evolving area. Since authors have been involved in development of cutting edge intelligent tutoring systems technologies for variety of uses and functions their contribution is valuable on global scale. Individual and group opinion is presented in alphabetic order of presenting author/authors. Finally, it is important to understand that this section present different point of view on the same domain. Opinions of contributors are their personal point of view and perceptions of the intelligent tutoring system field without any reviewers’ and editors intervention. We leave the reader to evaluate and choose the most valuable contribution that will serve as an inspiration for their research of the ever enchanting world of intelligent tutoring systems.

Julie Coultas

One very clear message that we can take from past experience with any information and communications technology is that users are getting younger and younger. On this basis can we make any predictions about the future? From my study of young children using electronic learning devices it seems that they are at ease with the technology (Coultas, 2008).

There are some research factions in developmental psychology (see Psychologist, 2007) who believe that young children do not need contact with educational technology – a cardboard box and some material is enough to stimulate imagination. But does this type of thinking really take into account how the cultural environment affects the child? Young children see their parents using handheld devices (e.g. Blackberry, iPhone), deeply engrossed in communication, downloading information and more often than not focusing their attention on these devices. Is it surprising that young children take an interest in these devices? They are following their parent’s direction of gaze.

In an impromptu study with my 8 months old young granddaughter, we gave her the choice of two communication devices. These devices were placed on the floor within crawling distance of the 8 month old. No matter how many times we repeated this experiment (moving her away from the two devices, moving the devices around, placing them screen down) she invariably chose one over the other. One reason, I propose, for this behavior is that her father uses the preferred device. She has watched her father and mother using a mobile and also a laptop computer. Children, even very young ones, imitate the people around them (Lightfoot, Cole and Cole, 2009; Berk, 2009). They observe their parents behavior and copy it (Bandura, 1977)
Infants enter their social world predisposed to copy and interact with the people around them. Nowadays a large part of our interaction and learning comes from our electronic devices. These are cultural tools. These tools not only change the way we interact and learn they also facilitate learning (Carr and Yuill, 2009). Is there an argument for delaying contact with these devices until the child is at a certain age? Perhaps delaying contact until the child has started full time formal education? The answers to these questions depend on whether we believe that children are disadvantaged or advantaged through contact with electronic learning devices. Do they stifle a child’s imagination and creativity? There is still plenty of debate in this area and more research needs to be undertaken to illuminate particular aspects of the technology that can facilitate children’s learning.

**Tonči Dadić**

Power of computerized expert of an intelligent tutoring system is based on teaching domain knowledge. Definition of such knowledge requires significant human expert effort, estimated to 100 – 200 hours of human work for each teaching hour. Authoring shells supporting knowledge representation by controlled natural language will make building of tutoring systems easier in acceptable period of time. Diagnoses of student’s program correctness and bug localization is an essential functionality of intelligent systems for teaching programming. Traditionally, it is provided comparing student’s program against model program. Complication arises because single programming task may be solved by various algorithms, and coded by different instructions, while algebraic and logical expressions may differ as well. Student’s program is semantically equivalent with model as long as both produce the same sequence of outputs for the same sequence of inputs. Diagnoses techniques that compare computational sequences of programs require complete models, predicting possible variations. Lack of model completeness implies false alarms that are considered very harmful in educational process. We believe that comparison based on semantics equivalence of programs would improve diagnoses, and simplify modeling of correct solution.

**Benedict du Boulay**

Various researchers are building educational systems that attempt to take the learner’s motivational, metacognitive and/or affective state dynamically into account (see e.g., Paiva, Prada, & Picard, 2007). For example, AutoTutor (Graesser, et al., 2008) has been instrumented to observe the facial expression and posture of the learner in an attempt to move the learner towards (or maintain the learner in) a positive learning state such as “engaged”, and also to move the learner away from negative learning states such as “bored”. In a similar vein, Kapoor and others (2007) have developed a system that is able to make a good estimate of when a learner is “frustrated” based on a number of features such as hand pressure by the learner on the mouse. These technologies are also now finding their way into mainstream education (Arroyo, Cooper, et al., 2009) and the more general issue of the affective dimension of human computer interaction is well established (Picard, 2000).

These kinds of system raise a number of theoretical and practical questions: What kinds of data are available on which to make inferences about the motivational, metacognitive affective states of the learner? What is the nature of the theory that links such data to inferred motivational, metacognitive and affective states? What kinds of motivational states are to be distinguished, one from another? What are the relationships between learning and either relatively stable personality traits or relatively transient
motivational states and feelings, or less transient affective states such as moods? What are the predictable trajectories between affective states over the duration of a lesson or of a course? And what is the nature of the theory that determines how a caring system might best assist the learner to move away from trajectories or states that might inhibit learning towards those that might enhance it? In other words, what is the nature of the theory that helps the learner follow a trajectory of states that enhances and opens new possibilities (see e.g., Kort & Reilly, 2002), even if there are individual negative episodes along the way, as opposed to a trajectory that limits possibilities and is dysfunctional or maladaptive, even if there are individual positive states along the way?

Curilem G.M., Vizcarra, B., Poo, A.M. Huenteman, D., Brasil, L.M.

Intelligent Tutoring Systems (ITS) stand in the intersection of education, cognitive science, artificial intelligence and human-computer interaction. They also are influenced by many pedagogical paradigms, like constructivism, behaviorism, collaborative learning, affective states, etc. These knowledge areas influence its modules implementations. Although, most of the systems developed until now have privileged some of the modules and some of the paradigms, it seems important to synthesize the different knowledge areas and develop more integral systems. However, in our opinion, cognitive sciences are the most important knowledge that ITS require to be more effectives, as it brings reliable information about how the learning process occurs. We consider that ITS can be used to evaluate cognitive hypothesis about learning and thus, may contribute to improve cognitive science knowledge. In our work we propose a methodology to develop an adaptive interface to some learning styles of the students. The system can be used to assess whether learning styles influence the learning process and even which styles are more relevant. This is why we believe that ITS are in an insipient stage of their development and they may have an enormous impact in education, not only to support learning but also to understand it.

Funda Dag, Kadir Erkan

Ontology based modeling approach is most appropriate implementation approach for the personalized e-learning systems. It supports a new sight to solve content related design problems of ITS and AEHS. By using ontologies, domain model and user model of the systems such as ITS have been recognized quite easily and in a flexible manner. But, today, there are some problems in inference mechanism and expressivity of the Semantic Web Tools. Because of that especially, methods or ways should be investigated to make more applicable the adaptation model of the personalized learning systems according to ontology based modeling paradigms. So, roadmaps of the personalized learning systems are specified according to researches and developments in the areas of DL based reasoning techniques and Semantic Web rule languages. Therefore, if more expressive rules have been written by rule languages, adaptation capabilities of the learning systems have been enhanced. In addition, if we see that the personalized learning system is a semantic web application, DL based reasoning engines should be designed to handle large-scale knowledge bases. So, efficient and effective analyses of large ontologies such as the learning ontology are being possible. Also, web services are important research and implementation areas for semantic web applications which can be designed distributed systems.
Jeroen Geuze, Egon L. van den Broek

In the early 70s, the idea of computer-based instruction emerged. With the human teacher as educational model, artificial intelligence (AI) were applied to achieve this goal. As became apparent in the next decades, ITS are a typical AI challenge. With ITS, their major challenge is threefold, it requires understanding of: 1) the behavior of human teachers, 2) the student’s behavior, and 3) their interaction. However, human teachers and their students are no homogeneous groups, they vary substantially in all possible aspects. Consequently, their interaction is highly complex. So far, true, flexible, generic ITS are far beyond science’s current research. A substantially deeper (multi-level) understanding of human beings is required. Perhaps then, decades from now, ITS will appear future instead of fiction.

Ani Grubišić

Although the ITSs are less effective than human tutors, they certainly influence positively learning and teaching process of students that use them. Anyway, the ITSs cannot replace teachers and they are not intended to do so, but they can ease and improve their work. The ITSs should be included in education as one method for learning and teaching, and results of meta-analysis can give directions for their selection and improvements.

In the future, more experiments with different ITSs in different domain knowledge areas should be conducted to see if domain knowledge influences effect size estimations. A new meta-analysis should be done for each domain knowledge and for each ITS separately, and include a larger number of experiments and a larger sample size, as well. In that way, it would be possible to make some conclusions about domain knowledge areas that are more appropriate for learning and teaching using particular ITS, as well as, how much are those ITS effective in general.

Divna Krpan, Suzana Tomaš, Roko Vludušić

Intelligent Tutoring Systems (ITS) provide the benefits of one-to-one instruction. There is a challenge on transferring to computers the skills of human teacher while overcoming space and time restrictions. There are studies that show that one-to-one human tutoring is more effective than other modes of instruction. ITSs support on line tutoring in different domains. They must be capable to accurately diagnose students’ knowledge, skills, and learning styles and then decide how to adapt instruction and provide feedback. The advances in computer technologies facilitated the development of ITSs. With advances of new technologies such as Web 2.0 there are new ways in which students learn. For example, social networking invokes collaboration of students. There are discussions if learners should interact with ITS individually or collaboratively. Collaborative learning imposes team or group work, which then implies group modeling. Group modeling requires different design techniques then student modeling, and it is not researched in same extent. ITSs should incorporate different learning strategies which also include group modeling support.

The interoperability of ITSs is a great advantage for sharing learning content, but it cannot be achieved without standardization. The most emphasized standard is SCORM. There is a problem because many of Web 2.0 technologies are not addressed in SCORM, and also there is not adequate support for all aspects of group modeling. The omissions of SCORM will hopefully be covered with work of the International Federation for Learning, Education, and Training Systems Interoperability (LETSI).
Evaluation of existing intelligent tutoring systems shows that such systems are often more effective than traditional learning and teaching. “Freedom” provided by this method of student’s learning requires more motivation, discipline and personal organization to fulfill given tasks on time. This method of learning and teaching can keep parents involved in the activities of their children. Although these systems can never fully replace live teacher, they can be great help in teaching.

Alke Martens, Andreas Harrer

Traditionally, the development of intelligent tutoring systems has been driven mainly by the knowledge engineering task to produce powerful and elaborate domain representations. As every complex system, ITSs tend to be hard to maintain over a longer time of usage and cannot be extended easily if not carefully designed also from a software engineering perspective. Thus, we observed increasing discussion and efforts to create ITS not from scratch, but by using framework systems (Aleven, McLaren et al. 2006), extensible knowledge representations (constraint-based tutors as of Mitrovic et al. 2007), and lightweight authoring techniques (e.g. the example tracing tutors (Aleven et al., in press) used in the Pittsburgh Science of Learning Center).

We expect that these lines of actions will gain increasing importance to create ITS faster, more efficient, and more flexible by adoption of established practice from the field of software engineering: ITS middleware approaches are called for, as well as sharing of design knowledge (in the form of patterns for software architecture, software design and pedagogical design) and of opening codebases to the field in open source initiatives (one first example is the encore community: www.encorewiki.org).

Abdolhossein Sarrafzadeh, Jamshid Shanbehzadeh, Scott Overmyer

Today’s intelligent tutoring systems are able to adapt their teaching strategies to the knowledge and abilities of individual learners. They have been demonstrated to be effective, with better learning outcomes than simple programmed instruction. Studies have shown that ITSs can even outperform traditional classroom instruction: they are always available, non-judgmental and can provide tailored feedback. Even so, we assert that one-to-one human tutoring is superior to intelligent tutoring systems. What we believe is missing in intelligent tutoring systems is the ability that human tutors have to adapt to the affective state of the learner. Existing tutoring systems, with few notable exceptions, such as Eve, are not able to do that. The authors believe that future intelligent tutoring systems will be able to adapt to perceived nonverbal behavior of the learner bringing them much closer in effectiveness to best human tutors.

Lung-Hsiang Wong, Chee-Kit Looi

With the rise of e-learning, online collaborative learning and mobile/ubiquitous learning, the ITS paradigm has been gradually shifting from a classic, single-machine setting to a modern, distributed and social construct which may be leveraging more on soft-computing techniques as feasible solutions to such potentially complex data processing and decision making processes in the new generation of learning systems.
Marija Zelić

The next generation of e-learning systems, and especially the intelligent tutoring systems, has to put even more emphasis on intelligence, adaptively, knowledge sharing issues, as well as reusability and interoperability. The latest research and development efforts, such as the Semantic Web and AI, provide means for semantic representation and organization of data - hence enabling semantic search, reasoning and integration of heterogeneous data, as well as creation of semantic web services for promoting reusability and interoperability of the e-learning systems. Intelligent agents can be deployed to perform automated discovery, composition and invocation of the services based on the learner profile and the current learning context. The agents, services as well as data can be distributed all over the world and offered by different organizations and universities. From this perspective, the e-learning system is envisioned as a collection of distributed components assembled on-the-fly for a specific purpose.

Branko Žitko

Even so intelligent tutoring systems (ITS) are converging to human tutor and possess many benefits that human tutor doesn‘t; there are still three global challenges. Those challenges can be characterized as ITS thinks, acts and reacts as a human tutor. Overall challenges lay on artificial intelligence and cognitive science, and are tending to mimic the way of how tutor brain works. Acting and reacting are also depending on ITS abilities to process large scale of information gained from and expressed to the student. Those two characteristics are based on accomplishment in a field of human computer interaction. It is proved that natural language processing has great impact on effectiveness of ITS, but other kinds of interaction with students, like virtual reality and other ways of expressing subject matter are procurable and successfully implemented today. On the other, tutor has to measure and react on student’s behavior, so biometric is a promising field specialized for collecting physical and behavioral data from the individuals.

REFERENCES


Afterword


