Challenges Involved in Making of Intelligent Tutoring Systems (ITS) and Future Considerations

Syeda Faiza Naz[1], Farheen Qazi[2], Rida Mughees[3], Komal Sarwar[4], Hana Mehmood[5]

AUTHOR`S AFFILIATION

[1,2,3,4,5]Department of Software Engineering, Sir Syed University of Engineering and Technology
Karachi, Pakistan,

ARTICLE INFORMATION

Received: 3-12-2019
Revised: 16-12-2019
Accepted:26-12-2019
Published Online: 31-12-2019

SUGGESTED CITATION

Naz S. F., Qazi F., Mughees R., Sarwar K., Mehmood H. (2019). Challenges Involved in Making of Intelligent Tutoring Systems (ITS) and Future Considerations. UJCSIT, Vol 2, No. 2, pp. 44-57

ADDRESS OF CORRESPONDENCE

Syeda Faiza Naz
fizzy.syeda@gmail.com

ABSTRACT

Intelligent tutoring Systems is a vast field and since it's birth in the 1970's it has been a topic of discussion. Research have done to enhance AI techniques to combine human and machine efforts for the profound provision of education that is impossible individually. There are many Intelligent Tutoring Systems that have been developed over the years with a common goal that is to deliver information effectively. Augmenting AI in classrooms has shown an improvised performance in the students through analyzing student behaviors and their responses.

This paper provides a broad and intense look at the challenges that are to be heeded while developing an ITS. This paper also provides a look at the future considerations of them.

I. INTRODUCTION

Artificial Intelligence has brought uncountable blessings upon mankind. In a world, where everything is smart or almost near smart. The world we live in, always expect the students to perform better every day, although this is rather superficial to expect this while adapting to the same trivial teaching methods. Classrooms are books that have become a little too old for the people who encounter a digital gadget every second.

We have also evolved enough to conclude that, every student cannot be provided with the same method of learning but rather it is required to produce personalized and customized techniques for learning to be implemented for each student. The previously said statement might come across as complicated, but the use of intelligent systems in the classrooms will be a great aid for the personalized teaching methods.

Classrooms are being left a little behind. If we dig down a little, it's been nearly 40 years since artificial intelligence in education (AIED) came to exist. CBT and CAI were the first systems to be used as an attempt for teaching using computers, the direction was not customized according to the requirements of the learner. But rather the decisions to push students through a teaching material were a script like, such as ``if question 20 is answered correctly, proceed to question 54; otherwise go to question 32." The learner's abilities were not also deemed [1],

Both CBT and CAI do not provide the same kind of individualized attention that a student would receive from a human tutor [2].

For a revolutionized and optimum learning system, it must account for the domain and the learner. This has evoked research in the field of intelligent tutoring systems (ITSs). ITSs offer greater scalability in the showcase of material and the potential to adjust according to the needs. These systems attain optimism by making pedagogical decisions about teaching well, as well as presenting information about the learner [1].

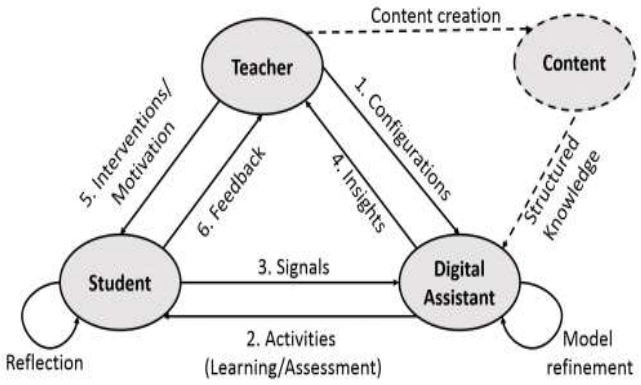

Fig 1: A general scenario of ITS integrated Classroom

ITS helps in the creation of the series of tasks that fits the needs of the learner, which aids teachers to draw their attention on more humanly tasks such as empathy and nurturing creativity [3] as shown in Fig 1.

In the above-given scenario, the traditional interaction between the student and teacher is integrated by digital assistance that initiates the personalized assessments and designed techniques for the student and then accounts the behavior and signals from the student and passes it on to the teacher. The teacher can further use the insights to come up with remediation for the continuous involvement of students in the learning process.

II. LITERATURE OUTCOMES

The earlier research has shown us the components [5]. for the ITSs and identified 4 main components that are the student model, the pedagogical module, the domain knowledge module, and the communication module. As shown in Fig 2, a new component has also been added called "Expert Module" [1].

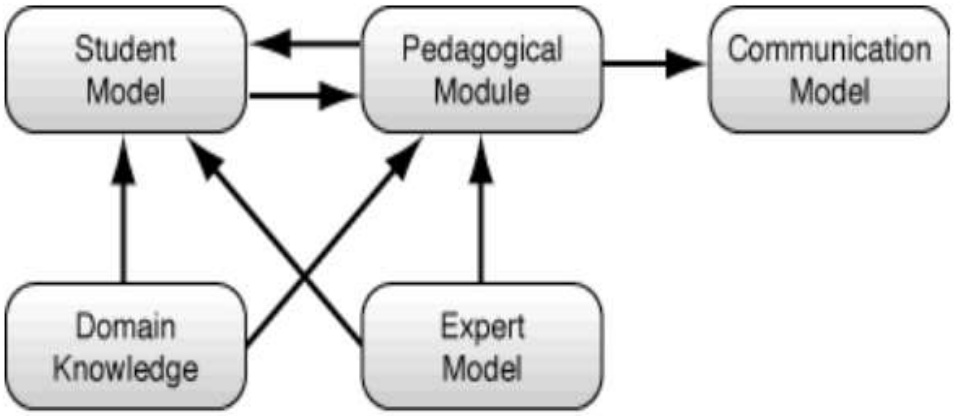

Fig 2: Interaction of Components

1. **Student Model:** It keeps track of how well a student is learning.
2. **Pedagogical Module:** This component demonstrates how to present a topic and when
3. **Domain Knowledge:** Holds about what is being taught.
4. **Communications Module:** It emphasizes how to present information in the most effective way.
5. **Expert Model:** it is a model of how an expert represents knowledge.

While talking about ITSs, an artificial teaching assistant called Scarlet has been developed, that intends to work with the question-answer scheme, but is highly adaptable to a vast range of different input schemes. The complete system can be divided into 3 major modules: natural language processing, pseudo contextual data analysis and trial & error learning [6].

Ilhan, K., Music, D., Junuz, E., & Mirza, S. (2017). Scarlet - Artificial Teaching Assistant. 2017 International Conference on Control, Artificial Intelligence, Robotics & Optimization (ICCAIRO).

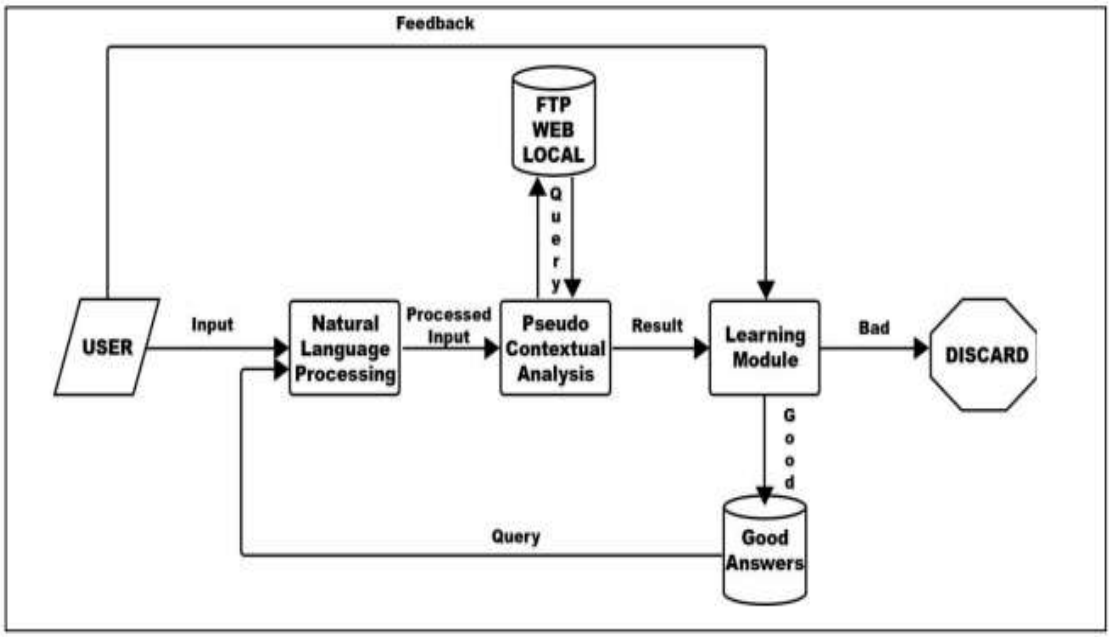

Fig 3: Step by Step Activity

In Fig 3, some ITS monitor step by step activity of the student [7] but some others make sure the provision reviews on the final solution only [8].

In some ITSs, the next activity is being selected while the others let the student do it. ITS research has successfully delivered techniques [9] and systems that provide adaptive support for student problem solving or question-answering activities in a variety of domains (e.g., programming, physics, algebra, geometry, SQL and introductory computer science).

The Andes, an ITS created to assist physics problem-solving at the university level [10] and includes a pair of an element the first element, known as the SE (Self-Explanation)-Coach, nurses example studying preceding problem-solving. The second element, known as the EA (Example-Analogy)-Coach, aids the efficacious use of examples during problem-solving (i.e., analogical problem-solving.

In the article [4] analysis has been performed on Answer, step, and sub-step-based tutoring shown in Fig 4. The answer based tutoring needs the student to first solve the problem as a whole, and then it provides the right answer. And if the student needs a hint it rather provides it in a bigger

picture. The step-based tutoring breaks down the answers in a series of steps. If the help is required, it could provide hints for solving those particular steps. In a substep-based system, there might be a remedial dialogue at a finer level than an individual step.

Comparison	No. studies	Mean effect size	Reliability (%)
Answer based vs. no tutoring*	165	0.31	40
Step based vs. no tutoring	28	0.76	68
Substep based vs. no tutoring	26	0.40	54
Human vs. no tutoring	10	0.79	80
Step based vs. answer based	2	0.40	50
Substep based vs. answer based	6	0.32	33
Human vs. answer based	1	−0.04	0
Substep based vs. step based	11	0.16	0
Human vs. step based	10	0.21	30
Human vs. substep based	5	−0.12	0

Fig 4: Evaluation between the types

The paper [3] further indicates that there are over half a million students benefiting from the cognitive tutors. They are aiding in the most effective ways of deeming step based learning in different subjects, especially mathematically related ones. This also helps teachers to maintain their focus on the other students.

III. BRIEF HISTORY OF PREVIOUS ITS

3.1. Auto-tutor [11]:

It was developed at the University of Memphis, and it exhibits the same techniques as the human tutor, it was developed to aid the university students in the literacy of computers. The auto tutor combines theories and architectures that are derived from the cognitive sciences. It possesses a talking head that is integrated with synthesized speech, start. intonation, facial expressions, and gestures. It emphasizes more on asking questions from students and what the student knows. Instead of being just an information delivery system it acts more of a discourse prosthesis.

1. **Modules:** There are seven modules of the Auto-tutor
2. **Curriculum script:** It puts in order the subjects and contents of teaching material.
3. **Language extraction:** It analyzes the words being put into the system.
4. **Speech act classification:** It is based on a neural network that identifies the speech in one of the seven categories Assertion, WH question, Yes/No question, Directive, and Short Response.
5. **Latent semantic analysis (LSA):** It is a method that flattens big texts s into a space of 100 to 500 dimensions.

6. **Topic selection:** the topics are selected by the rules that complement the learning ability of the student.
7. **Dialog move generator:** It is done by the use of an algorithm.

3.2. Atlas [12]:

It provided as a basis for the new generation of the ITSs. Although it was created to work with ITSs, but is rather domain-independent and is able to initiate communication with any system that supports the implementation of the API. It is a hierarchical task network (HTN) style, reactive planner as shown in Fig 5. It works with a host system that provides GUI support and domain knowledge via an API. Here, it is given the freedom to tutors make use of both natural language or the Graphical User Interface.

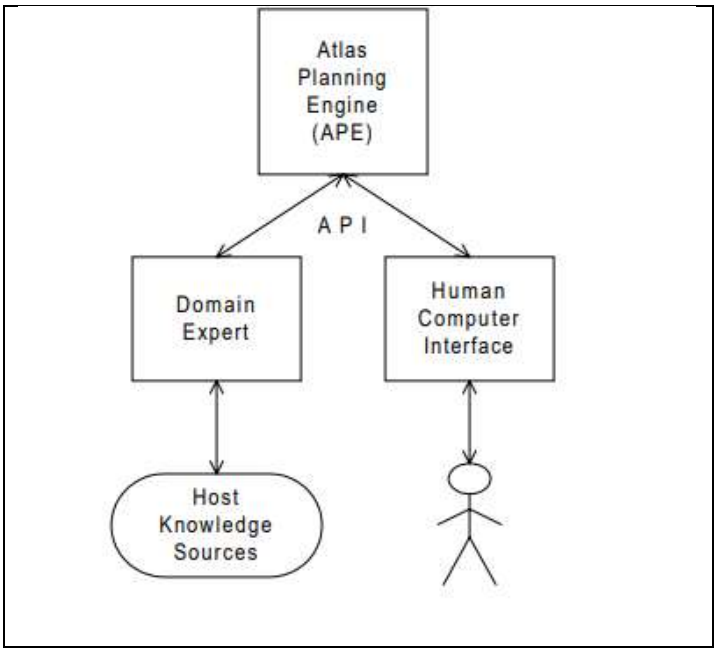

Fig 5: The interface of the Atlas

It makes the use of a Reactive Planning Algorithm that follows the following series of steps.

1. Consideration of the data input by the user
2. Analysis of the data
3. Find out the pragmatic import of the data
4. Making decisions on how to respond
5. Execution

3.3. WHY2 [13]:

It helps in learning physics, and instead of just delivering the information it rather sows the information learned by a series of questions and answers and putting up effective conversations. It requires the student to input a situation to relate to physics and then strikes the conversation by asking questions. WHY2 was intended to be a successor of one of the first intelligent tutoring systems in the literature, the WHY system. WHY was created and slightly executed by Albert Stevens and Alan Collins [14]. They studied experts aiding learners articulate such demonstrations and decided to add their tutorial techniques in the WHY system.

3.4. ANDRES:

Andres was developed at the Learning Research and Development Center (LRDC) at the University of Pittsburgh and the United States Naval Academy (USNA) [15]. Andres lets the students conclude a problem while making sure of the provision of an environment where every mandatory help is present like visualization, immediate feedback, and procedural and conceptual help. It consists of two modules the authoring module and the student module.

3.4.1. Student Environment:

It contains five major modules the action interpreter, the assessor, the interface, the help system, and the student model.

3.4.2. Authoring Environment:

The knowledge field behind the Andes determines physics queries by producing all the equations mandatory to figure out and the physics knowledge rules are used for the provision of domain knowledge underneath demonstration for each query. This field possesses almost 600 rules that are of two types: goal rules and physics-knowledge rules. The goal rules exist to supervise the system in the steps mandatory to achieve a solution path.

IV. CHALLENGES INVOLVED IN THE DEVELOPMENT OF ITS

4.1. Engaging Techniques and Methods

When taking a look at the teaching and learning perspectives, there is a subtle need to coming up with something that keeps the student engaged, interested and focused with the provision of the sound material that is equally effective and student-engaging [16]. Although this cannot be fulfilled unless the ITS has a profound knowledge of the child's strengths, weaknesses, likes and dislikes so that it could come up with the material that draws the student's attention and intensifies

the student's interest towards learning. The ITS is also required to teach complex concepts in a manner that easily enthralls the mind of young learners.

Research has also concluded that children have different sort of attitude towards learning, some learn more efficiently on their own while there are some students that learn more efficiently while being in groups [17]. This also needs to be taken into consideration while the implementation of ITS.

ITS also needs to come up with methods and techniques that synchronizes with the student's attributes and the requirements [18] for example, priorities, and disposition. The system also needs to take account of the emotions, learning patterns and behavior that includes cognition and metacognition of the learner to come up with effective strategies [19]

4.2. Being Flexible and Adaptive

The world that we live in, is evolving faster than the blink of an eye. New subjects are being introduced each year. On average, around 20 subjects a high school student has to encounter. Therefore, the ITS has to be adaptive and has to acquire new ways of teaching, and our problem is that we are teaching 21st-century subjects with the 18th-century ways of teaching. Our teaching consists of medieval methods that no longer serve the purpose of giving precise and fruitful information to the juvenile minds.

It is required to build the systems, that could help students in coming up with innovative ways of solving complex queries. Research is required to design ITS that compliments Inquiry-based learning. Because IBL supports mindsets in broadening their learning capabilities [20] [21]. It is also required to dig deep into the tools that could come in handy for enhancing creative abilities to keep up with the new subjects being introduced every year.

4.3. Analysis of the Behavioral Patterns of Students

Another great challenge for the ITS is to analyze the behavioral pattern of the students and make use of the data collected from different educational sources for a better understanding of the students and their learning patterns [22]. This needs to be done for coming up with the teaching patterns that totally fits the need of the students.

The system needs to reason about the success rate of the student based on the current skill, this could be done by only having the ultimate knowledge of the learning capability of the students. The reasoning under uncertainty is required for the ITS, for the successful delivery of knowledge e.g: The probability of the success of student A is N%, then it should present the forthcoming knowledge, based on that.

4.4. Evaluation of the Student's Progress

ITS also needs to detect whether the student has fully understood the concept or not or if the student has understood the concept partially. Then it must change its course if the student is having difficulty in understanding the defined concept. It should be familiar with the student's statistics, about the past history of the capability of acquiring knowledge, about where he/she is performing well and where it isn't and what are the success rates associated with each manner of teaching and this cannot be done without having a fitting detector that keeps a track on student's performance and makes decision-based on that. Here it is also needed for the ITS to understand what topic, the student is most interested in. Education is defined by the boundaries of i-e teachers, learning ability environment and time [22]. While learning should be free from all of the above.

4.5. Setting the Right Targets

Another one of the main challenges is to accurately define a target as a goal, and in order to rightly achieve the goal, it is required to rightly decomposing it to sub goals to achieve the required result. It is usually observed that the problem solving criteria has not been communicated to the student. Therefore, it is required to adequately define the goals and sub-goals and then later defining it to the student. An attempt was made to initiate interfaces that created explicit the goal structures that were only implicit in the instruction [23]. A proof graph in geometry was used to define certain relationships between the goals and sub-goals shown in Fig 6.

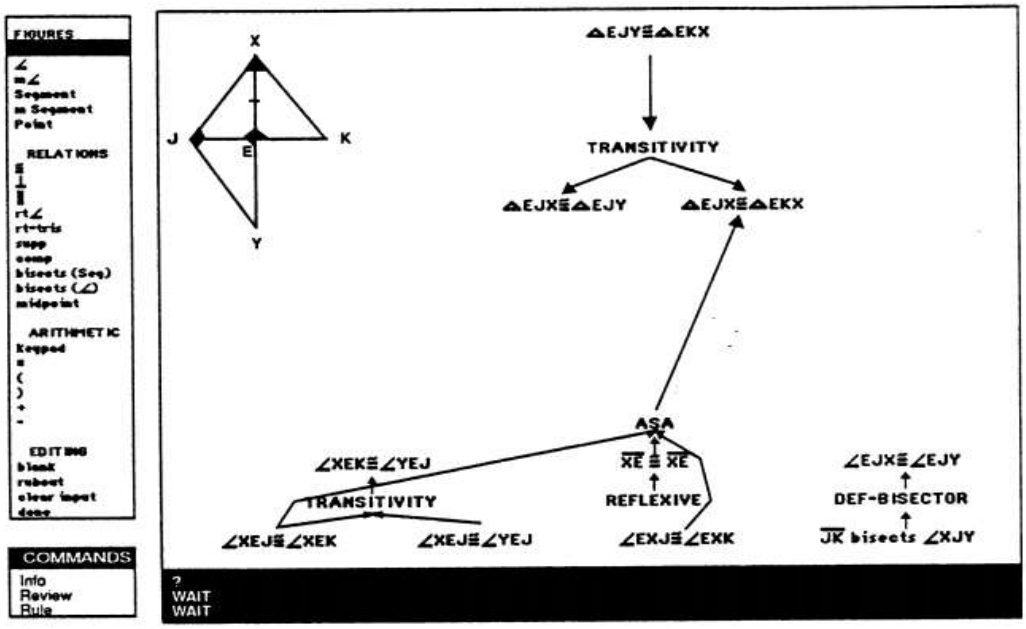

Fig 6: An image indicating the proof-graph formalism. The top contains the statement to be proved and the bottoms contain the given of the statement [25]

Fig 6: An image indicating the proof-graph formalism. The top contains the statement to be proved and the bottoms contain the given of the statement [25]

4.6. Determining The Cost

One of the main concerns of developing the ITS is the cost involved to develop and implement it. There is so much research required to determine what cost will be included for the development and implementation and coming up with a system that is both effective and viable.

There has to be proper communication and coordination between the people working for the organizations involved in the development of ITS. And this is also required to be in the defined budget and time constraints which is rather hard to follow up. A research shows that the development of cognitive tutor took a ratio of development time to instruction time of t 200:1 hours [24].

4.7. Need for The Evaluation Systems

There are no software or tools that could determine the viability or effectiveness of the ITS developed. This indicates that we have no way of knowing either the ITS being developed will play its part for the successful delivery of the information towards the students. The evaluation methods are yet to be defined that are also cost-effective. It is needed to come up with an inspector that determines ITS actually does what it claims to do. There are some evaluation techniques mentioned in the research but still, it is not known what evaluation technique to use in a particular domain [26] [27].

In upcoming days where ITS will be bulkley available in educational institutions, it will be needed for the evaluation systems to justify the usefulness of the ITS in order to cooperate the foster learning. Evaluations usually influence in what techniques the students learn and what they should be learning [28].

V. FUTURE CONSIDERATIONS FOR THE ITS

5.1. Ability to Understand Emotions

By understanding the emotions of a student, an ITS will be able to change its course of teaching [29]. Emotions come across as a great deal when it comes to learning. Because the feelings are associated with the emotions, understanding how a student is feeling that could be angry, sad, happy, curious an ITS will be able to respond adequately. One of the significant parts of the effectiveness of ITS is to respond to the situation sufficiently.

However, there is a rise in the shortage of mathematics and science teachers [30] and ITS will come in handy in order to resolve this issue.

5.2. Analysis for the gesture

Gestures are divided into three types when it comes to communication and they are

1. Deictic
2. Iconic
3. Metaphoric

They have different parts in communication. A system needs to accurately analyze those gestures and then take the forthcoming decisions based on the analysis. As the gestures are the unconscious way of describing how the particular person is feeling. In that way, it reveals more effective ways to teach students.

5.3. Replacement for the Homework

Students have always heeded Homework's as a burden and have mostly showed reluctance towards doing it. However, if the classrooms and teachers could come up with ways that will make the classrooms more interactive and student-engaging there would be no need for the homework and the students will be able to engage in more extra-curricular activities that would be healthy for both of their mental and physical health.

ITS have proved themselves as much as effective as one-on-one Human tutors especially when we are talking about STEM subjects. ITS must be designed in a way to outmaneuver homework, seatwork and other sorts of assignments releasing the burden on students. However, it must not exclude the whole classroom experience [31]

5.4. Building a Relationship with the Student

However, it may sound fictitious, but the truth is that a student is not able to learn effectively unless or until he/she is fully comfortable with the environment and the teacher and the student are in full harmony. The asynchronization between the student and the teacher makes it impossible for the student to learn and improvise.

There is a need for an ITS that could bridge the knowledge gap as well as the social distance between the student and the teacher and effectively builds a relationship with the student. Some steps can be taken here like smiling or calling students by their name [32] or asking about their day. It is also required to build such systems that will enhance the trust relationship and will be able to work on trust building.

5.5. Natural Language Processing

One of the main problems that lies is the evaluation of the answer provided by the student and it is associated with the NLP [33]. When the student's answers, the system checks its similarity with the required answers. However, if the NLP is not strong enough the system might confuse a right answer with the wrong one. Because a single line could be expressed in multiple ways.

There is a need of a system that could identify the correct answer even if it is given in a subtle way by the student and not confuse it with the wrong one.

VI. CONCLUSION

ITS are created with an aim to provide high quality education to the students by providing student engaging content and effective methods and strategies. Because, when it comes to human tutors, providing the explicit attention to each and every student becomes a rather difficult task.

ITS has proven its effectiveness over the years and might come as a productive alternative for the one on one human tutoring that not every student has access to. There is an immediate relationship between ITS and cognitive design and theories. There is research going on to prove the effectiveness of them.

However, there are still no evaluation techniques that could determine how much fruitful ITS are. And along with that there is also a need to come up with systems that ultimately satisfy the design consideration and surpass all the challenges that are mentioned way. By carefully observing the challenges and surpassing them will provide a way for designing ITS that will produce a gigantic impact in the tutoring world.

REFERENCE

[1] J Beck, M Stern, E Haugsjaa - Crossroads, 1996 - Applications of AI in Education

[2] Bloom, B.S. 1984. The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring. Educational Researcher, 13, pp. 3-16.

[3] Kokku, R., Sundararajan, S., Dey, P., Sindhgatta, R., Nitta, S., & Sengupta, B. (2018). Augmenting Classrooms with AI for Personalized Education. 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP).

[4] Du Boulay, B. (2016). Artificial Intelligence as an Effective Classroom Assistant. IEEE Intelligent Systems, 31(6), 76–81.

[5] Woolf, B. 1992. AI in Education. Encyclopedia of Artificial Intelligence, Shapiro, S., ed., John Wiley & Sons, Inc, New York, pp. 434-444.

[6] Ilhan, K., Music, D., Junuz, E., & Mirza, S. (2017). Scarlet - Artificial Teaching Assistant. 2017 International Conference on Control, Artificial Intelligence, Robotics & Optimization (ICCAIRO).

[7] Corbet A. T. and Anderson J. R. (1995). Knowledge tracing: Modeling the acquisition of procedural knowledge. Journal of User Modeling and User-Adapted Interaction 4(4).

[8] Mitrovic, A., Martin, B., Suraweera, P. Constraint-based tutors: past, present and future. IEEE Intelligent Systems, special issue on Intelligent Educational Systems, vol. 22, no. 4, pp. 38-45, July/August 2007
[9] Conati, Christina. "Intelligent tutoring systems: new challenges and directions." Twenty-First International Joint Conference on Artificial Intelligence. 2009.
[10] Conati C., Gertner A., VanLehn K., 2002. Using Bayesian Networks to Manage Uncertainty in Student Modeling. User Modeling and User-Adapted Interaction. 12(4) p. 371-417
[11] Graesser, A. C., Wiemer-Hastings, K., Wiemer-Hastings, P., & Kreuz, R. (1999). AutoTutor: A simulation of a human tutor. Cognitive Systems Research, 1(1), 35–51.
[12] Freedman, Reva. "Atlas: A Plan Manager for Mixed-Initiative, Multimodal Dialogue." (1999).
[13] Graesser, Arthur C., Kurt VanLehn, Carolyn P. Rose, Pamela W. Jordan, and Derek Harter. (2001) Intelligent Tutoring Systems with Conversational Dialogue. Al Magazine 22.4, 39-52.
[14] Stevens, A., and Collins, A. 1977. The Goal Structure of a Socratic Tutor. In Proceedings of the National ACM Conference, 256–263. New York: Association of Computing Machinery.
[15] Shelby, R. N.; Schulze, K. G.; Treacy, D. J.; Wintersgill, M. C.; VanLehn, K.; and Weinstein, A. (2001) The Assessment of Andes Tutor
[16] Kay, J. (2012). AI and Education: Grand Challenges. IEEE Intelligent Systems, 27(5), 66–69.
[17] Johnson, D. W., and Johnson, R. T. 1994. An Overview ofCooperative Learning. In Creativity and Collaborative Learning,ed. J. Thousand, A. Villa, and A. Nevin. Baltimore, MD:Brookes Press.
[18] Conati, C., and Kardan, S. 2013. Student Modeling: SupportingPersonalized Instruction, from Problem Solving toExploratory, Open-Ended Activities. AI Magazine 34(2).
[19] Bredeweg, B.; Arroyo, I.; Carney, C.; Mavrikis, M.; and Timms, M. 2009. Intelligent Environments. Paper presented at the Global Resources for Online Education Workshop,Brighton, UK
[20] Dragon, T.; Woolf, B. P.; and Murray, T. 2009. Intelligent Coaching for Collaboration in Ill-Defined Domains. In Proceedings of the 2009 Conference on Artificial Intelligence in Education:Building Learning Systems That Care: From Knowledge Representation to Affective Modelling, 740–742. Amsterdam: IOS Press.
[21] Floryan, M., and Woolf, B. P. 2013. Improving the Efficiency of Automatic Knowledge Generation Through Games and Simulations. In Proceedings of 16th International Conference on Artificial Intelligence in Education, Lecture Notes in Computer Science 7926. Berlin: Spring
[22] Baker, R. S. J. d.; Corbett, A. T.; Roll, I.; and Koedinger, K. R. 2008. Developing a Generalizable Detector of When StudentsGame the System. User Modeling and User-Adapted Interaction 18(3): 287–314.
[23] Laurillard, D. 2008. Digital Technologies and Their Role in Achieving Our Ambitions for Education. London: Institute ofEducation-London.
[24] Anderson, J. R., Corbett, A. T., Koedinger, K. R., & Pelletier, R. (1995). Cognitive Tutors: Lessons Learned. Journal of the Learning Sciences, 4(2), 167–207.
[25] From Rules of the Mind, p. 171, by J. R. Anderson, Ed., 1993, Hillsdale, NJ: Lawrence Erlbaum Associates, Inc. Copyright 1993 by Lawrence Erlbaum Associates, Inc.
[26] Iqbal, A., Oppermann, R., Patel, A. & Kinshuk (1999). A Classification of Evaluation Methods for Intelligent Tutoring Systems. In U. Arend, E. Eberleh & K. Pitschke (Eds.) Software Ergonomie '99 - Design von Informationswelten, Leipzig: B. G. Teubner Stuttgart, 169-181
[27] Siemer, J., & Angelides, M. C. (1998). A comprehensive method for the evaluation of complete intelligent tutoring systems. Decision support systems, 22(1), 85–102.
[28] P.H. Winne, A landscape of issues in evaluating adaptive learning systems, J. Artif. Intell. Educ. 4 4 1993 .
[29] Sarrafzadeh, A., Alexander, S., Dadgostar, F., Fan, C., & Bigdeli, A. (2008). "How do you know that I don't understand?" A look at the future of intelligent tutoring systems. Computers in Human Behavior, 24(4), 1342–1363.

[30] The Urban Teacher Collaborative. (2000). The urban teacher challenge: Teacher demand and supply in the Great City Schools. A study by The Urban Teacher Collaborative: Council of the Great City Schools, Recruiting New Teachers, Inc., and Council of the Great City Colleges of Education. Washington, DC: Council of the Great City Schools [Online].

[31] VanLEHN, K. (2011). The Relative Effectiveness of Human Tutoring, Intelligent Tutoring Systems, and Other Tutoring Systems. Educational Psychologist, 46(4), 197–221

[32] Wang, Ning; Gratch, Jonathan (September 2009). "Rapport and facial expression". 2009 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops. IEEE: 1–6.

[33] Rus, Vasile, and Arthur C. Graesser. "Deeper natural language processing for evaluating student answers in intelligent tutoring systems." Proceedings of the National Conference on Artificial INtelligence. Vol. 21. No. 2. Menlo Park, CA; Cambridge, MA; London; AAAI Press; MIT Press; 1999, 2006.