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Intelligent Learning System for Automata (ILSA) and the Learners' Achievement Goal Orientations

Cesar TECSON[a,b]
[a]*Ateneo de Manila University, Philippines*
[b]*Cor Jesu College, Philippines*
*catecson@cjc.edu.ph

Abstract: Studying automata theory exposes the students to the theoretical foundation of Computer Science where they learn abstraction, generalization, and reasoning. However, teaching and learning automata is challenging because of the involved abstract notions and mathematical background. Many students experience difficulty in understanding the computability concepts. Recent advances in teaching the course focus on the development of different pedagogical tools that can be used to facilitate the learning of automata theory and formal languages. Developments of tutoring systems for automata, like simulators, are continuously advancing. Fundamental efforts on features of automata simulators, based on the open literature, are focused on the following: visual creation, animation, conversion (transformation), interaction, logs generation, and saving and exporting facility. They do not support customization based on learners' performance in the tutor environment, like provision of individualized learning path and feedback. While these existing tutors facilitate teaching and understanding of the concepts, they do not focus on identifying whether learning is achieved.

Another factor that mediates student achievement is goal orientation. This theory suggests that students' behavior and response to the learning environment are guided by goals. Some students are performance-oriented while others are mastery-oriented. These personal goals interact with the learning environment, sometimes referred to as classroom goals. How these classroom goals align with students' individual goals can have an effect on both a student's achievement and learning experience.

Hence, the first goal of this study is to augment the capabilities of an automata simulator to characterize Intelligent Tutoring System (ITS) that is driven by a learner model to support individualized learning path, feedback, and support. The second goal of this work is to include features in the ITS that are intended to cater to the different achievement goal orientations of learners. The last goal would be to determine relationships among learners' in-tutor behavior, their goal orientations, and learning.

Keywords: teaching automata, achievement goal orientations, intelligent learning system, automata simulator

1. Motivation and Related Literature

Automata theory is the study of abstract computing devices, or "machines" (Hopcroft, J. E., Motwani, R., & Ullman, J. D., 2001). It deals with the definitions and properties of mathematical models of computation (Sipser, 2006; Kari, 2011) like Finite State Machine (FSM), pushdown automata (PDA), and Turing machine (TM). These models play important roles in several applied areas of computer science. They are vital to the understanding of how computer works (Sakarovitch, Thomas, & Thomas, 2009) as they are also used to model many different kinds of systems (Denning, Dennis, & Qualitz, 1980): digital circuits, human nervous system, mathematical systems, text processing, compilers and hardware design. Theory of computation allows practice with formal definitions of computation while introducing concepts, which are relevant to other non-theoretical aspects of computer science (Sipser, 2006).

Studying automata theory exposes the students to the theoretical foundation of Computer Science where they learn abstraction, generalization, and reasoning. However, teaching and learning automata course is challenging because the subject matter tends to be abstract and mathematical (Goya & Sachdeva, 2009). Hence, recent advances in teaching the course focus on the development of different pedagogical tools that can be used to facilitate the learning of automata theory and formal languages (Chakraborty, Saxena, & Katti, 2011).

Simulators are among the tools developed to help teach and learn automata. Chakraborty, et al (2011) presented a summary of five decades of automata simulators, facilitating the teaching and learning the abstract computational concepts of automata and formal languages. Automata simulators (Grinder, 2002; McDonald, 2002; Hamada, 2013) usually support visual creation of state machines, animation, conversion (transformation) of one computational model to another computational model (e.g. non-deterministic FSM to deterministic FSM), and interaction. These features enhance learner comprehension and contribute to a more positive learning experience.

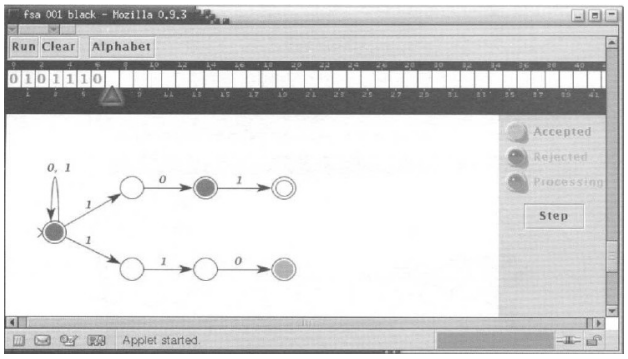

Figure 1. FSA Simulator environment (Grinder, 2002).

Another factor that mediates student achievement is goal orientation (Svinicki, 2005). Goal orientation refers to the motivation behind students' choice to engage in (academic) work (Anderman, 2015). This theory suggests that students' behavior and response to the learning environment are guided by goals. Some students may be motivated to earn good grades. These students are said to have a *performance goal orientation*. Others prioritize obtaining a better understanding of the course and the development of their own expertise. These students are said to have a *mastery goal orientation* (Mattern, 2005; Pintrich, 2000).

Table 1
The 2 x 2 achievement goal framework

		Mastery	Performance
Valence	Approach	Mastery-approach goal	Performance-approach goal
	Avoidance	Mastery-avoidance goal	Performance-avoidance goal

Table 1 shows the 2x2 achievement goal framework (Elliot, 1999; Elliot & McGregor, 2001). Mastery-approach individuals are interested in becoming proficient in an academic task. Mastery-avoidance people, on the other hand, are focused on avoiding misunderstanding the task or avoiding a mistake that happened in the past (Van Yperen, 2003; Van Yperen, 2006). Performance-approach individuals are interested in demonstrating that they are more proficient than others. Performance-avoidance individuals try to evade from appearing incompetent or stupid (Anderman, 2015).

These personal goals interact with the goals of the learning environment, sometimes called classroom goals. A teacher may give emphases on self-improvement to increase mastery and self-comparisons (mastery goal), or the emphasis is on competition, grades, and outperforming others (performance goal). How these classroom goals align with personal goals can have an effect on both student's achievement and learning experiences.

2. The Problem

This study attempts to address two problems. First, existing automata tutors typically focused only on building technical features like models supported, visualization, and animation. They do not support customization in the tutor environment, like provision of individualized learning path and feedback. In addition, while these existing tutors facilitate teaching and understanding of the concepts, they do not focus on identifying whether learning is achieved. Hence, one of the main goals of this study is to augment the capabilities of an automata simulator to characterize Intelligent Tutoring System (ITS), which is called Intelligent Learning System for Automata (ILSA). It would embed a learner model for the system to keep track of the learner's in-tutor performance. ILSA also aims to provide individualized learning path, feedback, and support. This study will also attempt to measure indicators of learning.

Second, students in a classroom setting carry different achievement goal orientations. Having different goal orientations among students makes it challenging for any teacher to cater all students' needs. Hence, this work will incorporate features for the ITS that provide for the different achievement goal orientations of learners.

Specifically, this study seeks to answer the following questions:

1. How does the learning model manifest in ILSA?
2. What ITS features are aligned with achievement goal orientations in ILSA?
3. How do the different types of learners actually utilize and respond to the system features?
4. How does the performance of learners in ILSA relate to actual learning outcomes?

3. Significance and Potential Contributions

First, this study addresses the limitations of the existing automata tutors that focus only on visualization and simulation while lacking on the implementation of adaptive tutoring feature. A tutoring system that is characterized by a learning model will be developed. The system somehow keeps track of the learner's performance while interacting with the tutor. It demonstrates flexibility by providing individualized learning path and feedback, which current simulators don't.

Second, a comprehensive literature review did not yield any findings regarding the study of achievement goal orientations in the area of teaching automata theory.

Lastly, earlier studies lack empirical efforts to assess whether learning has really taken place by using a simulator. This study addresses this concern by supporting logs to events and actions performed by the learner while using the tutor. These recorded events and actions will be used to find out indicators of learning.

4. Proposed Methodology

Generally, the study will follow the following steps below:

1. Build the intelligent tutor, ILSA, with features that would appeal to the different achievement goal orientations;
2. Profile students according to their achievement goal orientation;
3. Test the software with students.
4. Perform analyses on students' actual in-tutor behavior and performance to determine the features utilization across learners' achievement goal orientations;
5. Depending on the initial result, system may undergo revision then iterate back to #3.

4.1 Progress and Status

The *ILSA* has already been developed and underwent usability testing. Revisions are on-going based on the usability test results and suggestions. Next step will be the conduct of the study to target respondents from Philippines and India. Then, follows the analysis and interpretation of results.

4.2 ILSA Candidate Features

Based on the definitions of mastery and performance goal orientations, two (2) general categories of features were used in ILSA: *Scaffolding Features* and *Competitive Features*.

Table 2

ILSA Candidate Feature

	Feature	**Description**
Scaffolding	Hint	Suggestion or a tip directing to the correct answer.
	Glossary	Comprehensive discussion about the topic.
	Simulations	Exercises related to the current practice opportunity.
	~~Extra Challenge~~	~~Additional practice opportunity~~.
Competitive	Peer Reference	Other students' answers of a given practice opportunity
	Rank / Leaderboard	Rank of the student vs other students who are in-tutor.
	Badges / Ribbons	Reward for answering within the time threshold.
	Scoreboard	Total points.

References

Anderman, E. (2015). Goal orientation theory. Education.com. Last access: July 8, 2016.

Chakraborty, P., Saxena, P. C., & Katti, C. P. (2011). Fifty years of automata simulation: a review. *ACM Inroads*, *2*(4), 59-70.

Denning, P. J., Dennis, J. B., & Qualitz, J. E. (1980). Machines, languages, and computation.

Elliot, A. J. (1999). Approach and avoidance motivation and achievement goals. *Educational Psychologist, 34,* 169-189.

Elliot, A. J., & McGregor, H. A. (2001). A 2 × 2 achievement goal framework. *Journal of Personality and Social Psychology, 80,* 501-519.

Goyal, M., & Sachdeva, S. (2009). Enhancing Theory of Computation Teaching through Integration with other Courses. *International Journal of Recent Trends in Engineering*, *1*(2), 137-140.

Grinder, M. T. (2002). Animating automata: A cross-platform program for teaching finite automata. In *ACM SIGCSE Bulletin* (Vol. 34, No. 1, pp. 63-67). ACM.

Hamada, M. (2013). Turing Machine and Automata Simulators. *Procedia Computer Science*, *18*, 1466-1474

Hopcroft, J. E., Motwani, R., & Ullman, J. D. (2001). Introduction to automata theory, languages, and computation. *Acm Sigact News*, *32*(1), 60-65.

Kari, J. (2011). Automata and formal languages. *University of Turku*.

Mattern, R. A. (2005). College students' goal orientations and achievement.*International Journal of Teaching and Learning in Higher Education*, *17*(1), 27-32.

McDonald, J. (2002). Interactive pushdown automata animation. In*ACM SIGCSE Bulletin* (Vol. 34, No. 1, pp. 376-380). ACM.

Pintrich, P. R. (2000). Multiple goals, multiple pathways: The role of goal orientation in learning and achievement. *Journal of educational psychology*, *92*(3), 544.

Sakarovitch, J., Thomas, R., & Thomas, R. (2009). *Elements of automata theory* (Vol. 6). Cambridge: Cambridge University Press.

Sipser, M. (2006). *Introduction to the Theory of Computation*(Vol. 2). Boston: Thomson Course Technology.

Svinicki, M. (2005). Student goal orientation, motivation, and learning. *Idea Paper*, *41.*

Van Yperen, N. W. (2003). Task interest and actual performance: The moderating effects of assigned and adopted purpose goals. *Journal of Personality and Social Psychology, 85,* 1006-1015.

Van Yperen, N. W. (2006). A novel approach to assessing achievement goals in the context of the 2 × 2 framework: Identifying distinct profiles of individuals with different dominant achievement goals. *Personality and Social Psychology Bulletin, 32,* 1432-1445.