Towards Interest-based Adaptive Learning and Community Knowledge Sharing

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***Abstract*—We propose a System for Adaptive Interest-based Learning (SAIL) that utilizes community knowledge sharing (crowd-sourcing) strategies to empower adaptation of examples and practice problems based on students' individual interests. Personalizing education based on interest can lead to increased intrinsic motivation and positive learning outcomes. While most studies have been conducted manually, adaptive learning technologies offer a new approach to widespread incorporation of adaptive interest-based materials. The difficulty in widespread implementation is the enormous effort required to create customized content. SAIL aims to provide a framework for educators to access and contribute adaptive materials via community knowledge sharing within an easy-to-use adaptive learning system.**

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1. Introduction

Individualized instruction is the concept that instruction and/or materials should be customized to the unique needs of each student. Manual efforts to personalize education have been common practice - for example, if a student is struggling with addition, the teacher may assign extra homework problems for practice. Using technology to individualize instruction via an adaptive learning system (ALS) has been a widely studied research area over the last several decades. Adaptive learning strategies have been shown to improve student performance, with adaptation usually based on a student's previous knowledge, pace, or learning style [1]. This research takes an alternative, less-explored approach by enabling the adaptation of content, practice problems, and examples based on a student's interests.

Incorporating personal interest into learning has been shown to increase intrinsic motivation and provide positive learning outcomes [2]. Most studies of personalized interest in education have been implemented manually, but initial studies incorporating personal interest into adaptive technologies have indicated tremendous potential [3]. While adapting educational content based on student interest can be advantageous, widespread incorporation is difficult due to the enormous amount of instructor effort required to develop custom content.

We propose a System for Adaptive Interest-based Learning (SAIL)- a web-based adaptive learning framework that supports community knowledge sharing (crowd-sourcing) of adaptive materials to address these limitations and empower adaptation based on interest. The vision is to provide a framework where educators from multiple domains can contribute to and access adaptive content available to the community to provide students with an improved and individualized learning experience.

2. Background

2.1. Adaptive Learning

Adaptive learning is the notion of using computers as interactive teaching devices to adapt to the user's individual needs. It combines the fields of Computer Science, Education, Psychology, etc. Adaptive Learning is a broad term with many varying implementations such as: Adaptive Educational Hypermedia, Intelligent Tutoring Systems, and Adaptive eLearning. It is primarily used in educational settings such as classrooms and business training.

While Adaptive Learning has been widely researched with many reporting success, many challenges still exist. Creating a successful adaptive learning system is difficult, time-consuming, expensive, and usually geared towards one particular domain [1]. Recent research explores the use of authoring tools - designs to customize an adaptive system to work across multiple related domains [4]. Widespread integration of adaptive learning in education relies on the continued improvement of adaptive learning technologies and authoring tools [1].

2.2. Personalization

Adaptive learning strategies typically adapt based on a students previous knowledge, pace, or learning style [1]. This research takes an alternative, less-explored approach by adapting content, practice problems, and examples based on a students interests while.

Many studies have demonstrated that self-reference and context personalization have influenced student memory and learning [5]. The Self-Reference Effect [6] has been extensively studied and has shown that the customization of information to relate to the self or someone closely associated with the self can lead to learning improvement including better recall, transfer, and retention of information [7], [8], [9]. Recent studies evolving from the SRE have demonstrated that the the customization of content to include students' familiarities and interests (personalized context)

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has shown significant benefits in student learning. Most of the studies to this date have been manually conducted - without the use of any adaptive technologies. Initial studies using adaptive technology as a medium for personalized context have suggested positive learning outcomes [5]. Most notable is a 2013 study that personalized word problems in one unit of an Algebra course with an Intelligent Tutoring System (ITS) as the educational medium. Students who received word problems with personalized context had better and faster performance on the affected unit of instruction and demonstrated positive outcomes in abilities to transfer knowledge and retain information [3].

While results have been overwhelmingly positive for the incorporation of student interest in educational content creation, widespread incorporation is difficult. Most studies have been conducted in the field of mathematics where key words can be easily substituted into generic word-problems [5]. This approach limits the domains in which personalized context can be implemented and also the depth of which problems can relate to student interests. Many STEM fields such as computer science, engineering, and mathematics are highly applicable with other disciplines and the world around us. Utilizing the interconnectivity of these subjects with the world around us could be immensely beneficial in correcting the low enrollment, retention, and diversity issues that these STEM fields often suffer. Imagine a world where a student athlete could learn how to program based on sports related examples while another student in the same class could learn programming through science examples. To accomplish such a task, more effort would need to go into customized content creation - a task that would quickly bottleneck if created in isolation.

We propose a framework that supports community knowledge sharing (crowd-sourcing) of adaptive materials to address these limitations. Creating and encouraging the use of online knowledge sharing communities for educational resources is an effort being explored by many top universities. In the Computer Science community, efforts such as Stanford's Nifty Assignments project seek to collect 'interesting' CS assignments for reuse to help improve CS education (nifty.stanford.edu). Similarly, UC Berkeley's Ensemble project seeks to establish a digital library for computing education, with current research in participation encouragement through ranks/badges (computingportal.org). As we move towards the sharing of educational resources in online communities, more work is needed to encourage participation, organization, and optimize utilization of these materials.

3. SAIL

We are currently developing SAIL - System for Adaptive Interest-based Learning. The goal of SAIL is to provide a system where educators from multiple domains can contribute to and access adaptive content available to the community to provide students with an improved and individual learning experience. SAIL is the evolution of ALICE (Adaptive Learning for Interdisciplinary Collaborative Environments), developed by UGA as a revolutionary adaptive learning system for interdisciplinary instruction, but is being significantly expanded to accomplish two important missions:

1) Provide an adaptive learning system based on community knowledge sharing (crowd-sourcing) of educational content to alleviate the enormous task of content creation from the instruction.
2) Provide a framework for adaptation of practice problems and examples based on a student's interests. Initial studies of the incorporation of students' interests into adaptive learning systems have demonstrated many positive learning outcomes, but no widespread solution exists to address existing limitations by domain or instructor. Through community knowledge sharing, SAIL offers a novel solution to the problem of adaptive interest-based learning.

3.1. Community Knowledge Sharing

ALICE was initially designed as a system to empower transdisciplinary knowledge acquisition by providing students with a personalized syllabus based on their previous knowledge to help students from varying background collaborate on interdisciplinary problems [10]. ALICE was piloted in the Spring 2017 semester and the numerous changes to instructional design and planning that must be considered when transitioning to an adaptive learning system were documented [10]. Though certain adaptations to instructional design should be anticipated when transitioning to a new teaching method, the enormous effort currently required by the instructor to develop adaptive content is an obstacle preventing widespread incorporation and success. Even with the most dedicated educators, keeping up with the demand needed to implement ALICE in the Systems Biology pilot study was a struggle. These observations identified a clear need for community knowledge sharing in adaptive learning systems.

SAIL transforms the approach to adaptive learning by providing a medium for community knowledge sharing of educational content. The framework for the organization, storage, and retrieval of educational content is in early development. Once complete, educators will be able to search for content using keywords to find lectures, practice problems, and supporting material to utilize in their instruction. The usability of such a system is important for widespread success and is considered at every step of the design phase. An interactive drag and drop map is being developed to allow instructors to easily add content (via uploading or reuse of community resources) and create adaptive branches in course instruction. Students will also be presented with an interactive map where they can track their progress and see their unique adaptive path highlighted throughout the course.

3.2. Interest-based Adaptation

A common issue in traditional instruction is a lack of meaningful connections between what is being taught and how these concepts apply to the real-world. For example, a student learning introductory programming may learn how to print out the numbers 1-10 with a for-loop but not understand how learning such a concept could be applicable. Even when instructors provide examples to show the interconnectivity with the real world, it is impossible for a single example to be of interest to all students in the class. An example problem that uses baseball to teach some fundamental skill would intrigue only a subset of the students involved in the course, as some students may be uninterested in sports or may be from different backgrounds and not understand the rules. Problems such as these exist in the traditional instructional setting where all content, practice problems, and assignments depend on the unique instructor and are universal for all students. SAIL addresses this problem by adapting the learning content to a student's individual interests to ensure that each student is taught new ideas in a meaningful way.

It has been shown that increasing student interest while learning leads to a better overall learning experience - specifically impacting attention, goals, and level of cognition [2]. However, developing adaptive content is time consuming and too large a task for a single instructor. SAIL provides a unique opportunity to allow this adaptation of practice problems and exercises based on students interests through the incorporation of a community knowledge sharing framework.

In the evolution from ALICE to SAIL, there are some significant differences in both ideology and adaptivity. ALICE's adaptivity was implemented through a network connecting multiple disciplines, while SAIL evolves to include *intradisciplinary* adaptivity - aiming to highlight the interdisciplinary nature of many STEM fields (Computer Science, Mathematics, Statistics, Engineering) through interest-based learning to show the impact and interconnectivity with other surrounding fields. With ALICE, students learn different content at different paces with multiple starting points and end goals. While this interdisciplinary design is still supported in SAIL, the adaptive framework is expanded to support linear traversal through lexias/lessons in a predetermined order while adapting practice problems and examples to a student's individual interests. The design of this adaptive framework can be seen in Figure 1. For example, students in an introductory programming course would all have the same lesson on loops but will then follow a path of examples and practice problems based on their indicated interests. A student interested in Biology may take one path where they practice loops with Biology-related examples and problems, while other students may encounter problems in other domains such as PE, English, or Chemistry.

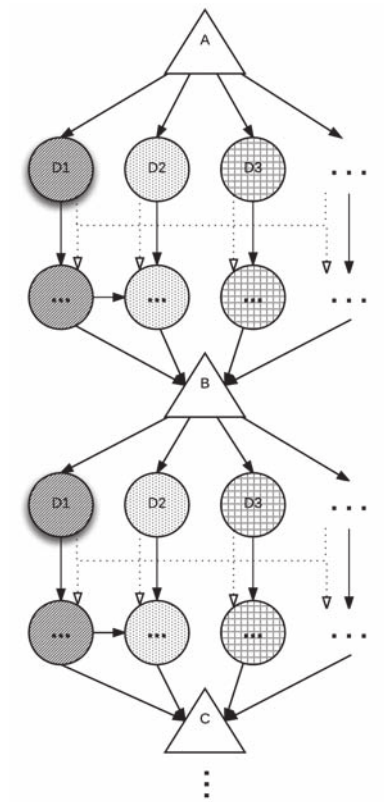

Figure 1. Knowledge Map for SAIL-CS. Students will move through a linear ordering of lexias: A, B, C, ... Practice problems and examples will branch off based on the student's interests (D1, D2, D3, .. Dn) Students may follow the adaptive path (solid arrows) or adapt their own path (indicated by dotted arrows) through the examples.

4. Conclusion

SAIL is currently in active development at the University of Georgia with an anticipated pilot study (SAIL-CS) in an Introductory Programming course expected in Fall 2017. Computer Science, like many other STEM fields suffers from low enrollment and diversity issues. As computer science touches nearly every part of our daily lives, adapting the way it is taught based on a students other interests could help attract and retain a larger and more diverse population of computer scientists. SAIL is designed to be a highly scalable system that could be used by many courses and evolve over time to include more content and interest-based problems through community contribution (crowdsourcing). Our hypothesis is that SAIL can positively impact STEM education at a very broad scale.

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References

[1] K. Aguar, H. R. Arabnia, J. B. Gutierrez, W. D. Potter, and T. R. Taha, "Making cs inclusive: An overview of efforts to expand and diversify cs education," in *Computational Science and Computational Intelligence (CSCI), 2016 International Conference on*. IEEE, 2016, pp. 321–326.

[2] S. Hidi and K. A. Renninger, "The four-phase model of interest development," *Educational psychologist*, vol. 41, no. 2, pp. 111–127, 2006.

[3] C. A. Walkington, "Using adaptive learning technologies to personalize instruction to student interests: The impact of relevant contexts on performance and learning outcomes," *Journal Of Educational Psychology*, vol. 105, no. 4, pp. 932–945, 2013.

[4] S. Devasani, "Intelligent tutoring system authoring tools for non-programmers," 2011.

[5] A. M. Sinatra, "–a review of self-reference and context personalizationin different computer-based educational domains," *Design Recommendations for Intelligent Tutoring Systems: Volume 4-Domain Modeling*, vol. 4, p. 107, 2016.

[6] C. S. Symons and B. T. Johnson, "The self-reference effect in memory: a meta-analysis." *Psychological bulletin*, vol. 121, no. 3, p. 371, 1997.

[7] D. J. Turk, K. Gillespie-Smith, O. E. Krigolson, C. Havard, M. A. Conway, and S. J. Cunningham, "Selfish learning: The impact of self-referential encoding on children's literacy attainment," *Learning and instruction*, vol. 40, pp. 54–60, 2015.

[8] R. E. Mayer, S. Fennell, L. Farmer, and J. Campbell, "A personalization effect in multimedia learning: Students learn better when words are in conversational style rather than formal style." *Journal of Educational Psychology*, vol. 96, no. 2, p. 389, 2004.

[9] R. Moreno and R. E. Mayer, "Engaging students in active learning: The case for personalized multimedia messages." *Journal of Educational Psychology*, vol. 92, no. 4, p. 724, 2000.

[10] K. Aguar, C. C. Sanchez, D. B. Beltran, S. Safaei, M. Asefi, J. Arnold, P. Portes, H. R. Arabnia, and J. B. Gutierrez, "Considerations on interdisciplinary instruction and design influenced by adaptive learning. sail-sb: A case study involving biology, computer science, mathematics, and statistics," *arXiv preprint arXiv:1703.06010*, 2017.