An AI-Driven Personalized Learning System (APLES) in Undergraduate STEM Education: Implications for Minority Students

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We are proposing an idea to develop an artificial intelligence (AI)-driven learning system for 1) giving undergraduate students personalized care on actively learning STEM fields in the classroom and beyond and 2) providing dashboard information on both students and their instructors to allow them to better understand each other, so that undergraduate STEM education and student learning become a more proactive practice in the future.

BACKGROUND

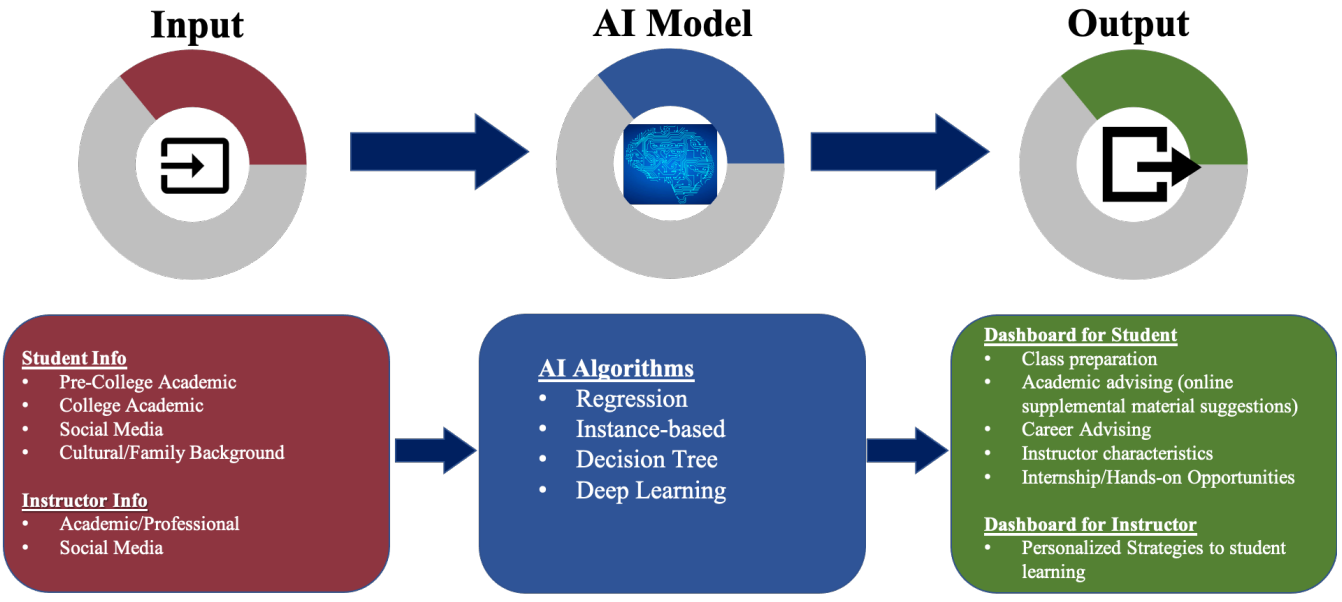
As technology continues to evolve and develop, it's become inevitable that enhanced tools from emerging technology will deeply impact our lives. The rapid development of AI has touched on all industries including education. With its powerful processing and predicting ability that can transform fast, personalized and targeted curation of content, AI will no doubt revolutionize learning and instructing from the perspectives of teachers, administrators, students, and colleges. The recent report from NSF demonstrates that the predominance in science and technology of the U.S. has continued to erode over the last decade. To keep the U.S. leading in the fast advancement of technology, educators have to accommodate the demand for a well-trained and well-prepared diverse STEM workforce. In addition, the lower participation of minority groups signals a lack of diversity in the STEM workforce that inhibits productivity and innovation. According to the Science and Engineering Indicators 2018 from the National Science Board, occupations and higher degree holders' percentage of minority groups in the engineering workforce have the lowest number compared to all other general groups. Furthermore, the current minority groups have demographically increased and will soon become the majority in the working age. Thus, students in the future will need a high technology equipped quality education for all racial groups.

Riegle-Crumb et al. (2019) demonstrated that minority students have shown high interest in engineering majors. However, they also concluded that a large population of these minority students are either switching or dropping their engineering majors at an alarming higher rate (40%) than their peers (29%). One of the main issues among two- and four-year engineering programs is that they are highly structured with integrated courses, which require good preparedness. In addition, universities are not equipped to handhold each student about their preparedness or academic work until a final grade is assigned. Although some researchers propose utilizing additional academic advising/counseling to minority students to address the problem, recent research shows

that it faces structural challenges due to cultural unfamiliarity, high caseloads, and multiple campus responsibilities. Moreover, the advisors/counselors are often biased when providing course/career advising to students, which further affects students' academic outcomes. Even worse, nationally in 2016, 57.3% Hispanic students are first-generation college students and their families lack sufficient "college knowledge," thereby limiting the information obtained at home. Thus, a successful preparedness and real-time information exchanging between students and instructors are difficult to achieve. The dire situation strongly calls for help from innovative education technologies in the undergraduate STEM education ecosystem.

INNOVATIVE TECHNOLOGY

In this proposed idea, AI is introduced to develop a learning system, **AI-Driven Personalized Learning System (APLES)**, for both instructors and students during their whole teaching and learning process in each class, as shown in the diagram below. On the contrary to the current practice, the system will take multi-dimensional data covering academic and non-academic aspects of both the students and their instructors. One the most innovative aspects is that APLES will be fed the "whole" information available from both students and instructors to allow AI's early interventions to 1) identify students' knowledge deficiencies in the learning process, recommend online learning resources as supplementary material, gather peers with similar issues into a study group, and even link local hands-on/internship opportunities to students; and 2) bridge students and their instructors to better understand each other's "personal" characteristics so that learning becomes a two-way process, which would strengthen a more proactive learning, especially for the future iGen and minority students. The diverse INPUT and OUTPUT data in APLES are provided in detail in the diagram.



INTELLECTUAL MERITS

The central goal of our interdisciplinary idea is to employ AI technology, along with other qualitative and quantitative research, to better discover barriers and opportunities to promote persistence of minority students in STEM majors. First, the local community coalition including K-12 schools, community colleges, 4-year universities, non-profit organizations, and companies is organized to explore barriers and opportunities facing the broad range of minority students and to leverage stakeholder relationships to lay the groundwork for a broader and more formal coalition focused on STEM education. Second, mixed research methods will be performed on minority students and stakeholders and generate the data to better understand insights of these barriers. Third, we will apply AI and other big data processing algorithms to extract the patterns hidden inside of the generated data. Fourth, based on the patterns in generated data, we will develop an AI-driven academic path prediction framework that can provide unbiased and personalized advice to individual minority students. The successful implementation of APLES can enhance our understanding of personalized advising and how it affects minority student success through the AI advisor, who understands individual's culture, personalized information, weakness and strengths to make an unbiased academic advising. Fifth, we will develop several interventions in the engineering course and measure their impacts. Utilizing the systemic analysis and AI-assisted framework, our findings can represent major theoretical and innovative contributions to the field of STEM education. The tools and implemented techniques and approaches in this project can also benefit other minority-serving institutions at the national scale.

BROADER IMPACTS

The project will construct a dynamic linkage between industry and education to promote minority populations in STEM majors. The proposed interventions include industry-integrated research and peer-mentor programs to broaden STEM participation by incorporating members of underserved groups from our communities. Moreover, these activities can raise awareness around minority students within STEM education. Furthermore, our techniques will offer an AI-assisted key tool to benefit the STEM education research.