Enhancing AI Education at an MSI: A Design Based Research Approach

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Abstract

While students are often passionate about their chosen fields, they often have limited awareness of the profound impact of AI technologies on their professions. In order to advance efforts in building subject-relevant AI literacy among undergraduate students studying Computer Science and non-Computer Science (Criminal Justice and Forensic Science) it is imperative to engage in rigorous efforts to develop and study curricular infusion of Artificial Intelligence topics. Using a Design-Based Research model, the project team and the external evaluators studied the first iteration of the module development and implementation. Using data collected through surveys, focus groups, critical review, and reflection exercises the external evaluation team produced findings that informed the project team in revising and improving their materials and approach for the second iteration. These efforts can help educators and the AI module developers tailor their AI curriculum to address these specific areas, ensuring that students develop a more accurate understanding of applications of AI in their future career field.

Introduction

There is a dramatic increase in the impact of Artificial Intelligence (AI) on society and its potential benefits. In turn, the need to increase educational efforts to prepare students to understand the Social Relevance and Trustworthiness of Artificial Intelligence in their areas is imperative and cross-disciplinary. There were three main goals of our project:

1. To improve career preparation of computer science (CS) and non-CS students at Fayetteville State University (FSU) by promoting deeper awareness of AI/Machine Learning (ML) use, knowledge of cross-disciplinary socially relevant applications, and understanding of associated ethical considerations (Berk 2012).
2. To enhance STEM pedagogy to increase retention of under-represented students in CS and Forensic Science (FS) by actively promoting Process Oriented Guided Inquiry Learning (POGIL) use (Hu et. al. 2016).
3. To create an evidence-based effective curricular modules that promotes AI/ML knowledge and enhances interest in CS, FS, and other related careers.

As part of the research agenda, the external evaluation team utilized a Design-based Research (DBR) approach to test and provide feedback on the developing POGIL materials. This systematic methodology is common in curriculum development in education and involves an iterative process of design, testing, evaluation, and reflection between researchers (Oh et. al. 2010) and practitioners (Wang et. al. 2005). The DBR approach was led by Cynosure Consulting, an organization led by researchers trained in educational psychology, measurement, and research methods who specialize in evaluations of innovative STEM education programs designed to enhance participation and success of underrepresented students in STEM.

Methods

The DBR process "consists of four phases: (1) analysis of practical problems by researchers and practitioners working in collaboration; (2) development of new solutions informed by existing design principles; (3) iterative cycles of testing and refinement of solutions in practice; and (4) reflection to produce design principles and enhance solution implementation (Easterday et. al. 2014). Each of these phases was operationalized by the project. See overview in Figure 1.

Module Design and Implementation

The project team proports that computing and non-computing curricula can benefit from customized modules that expose students to the knowledge of AI and the trustworthiness of AI models (Jain et. al. 2020). For the verification of this hypothesis, the following intervention tools were planned, developed, and studied.

- The Process Oriented Guided Inquiry Learning (POGIL) AI modules for creating inquiry-based activities that will be completed by students in teams in computer science (CS), criminal justice (CJ), and forensic science (FS) courses;
- Videos enhancing students' understanding of how AI models work and how to assess trustworthiness; and
- Educational materials to support the adoption of AI in non-computing disciplines and to strengthen the computing curricula with content that has traditionally not received adequate coverage.

To do this, the project leveraged an existing AI tool, ChatGPT. ChatGPT allows the generation variety of stories, essays, evaluations of these essays and much more (The Atlantic 2022). Practically any activity based on written human communication can be now affected. With fundamental enhancements in ML functionality, there will be a dramatic increase in many related applications. Following ChatGPT's release (OpenAI 2022) the use of older methods like filtering and moral/ethics-based model training have been found inadequate with the newest developments. Experimenters have shown how easy is to circumvent GPT3.5 learned "moral compass" (Substack 2022) while attempts are made to continuously build applications that may help humans in meaningful and profound ways (Czejdo et. al. 2021). The initial iteration, described in this paper, focused on giving students an understanding not only of concepts, but also of the limitations of AI by leveraging ChatGPT.

The POGIL module implementation inspired by existing work in science courses (Vincent-Ruz et. al. 2020), engaged undergraduate students in criminal justice and forensic science courses in a guided inquiry learning activity designed to introduce them to artificial intelligence platforms through engagement with ChatGPT. This activity aimed to build foundational knowledge of AI and to explore its reliability and trustworthiness. Students were divided into groups and assigned traditional POGIL roles such as Manager, Recorder, Reflector, and Presenter to encourage collaborative learning and effective group interaction (Kussmaul et. al. 2014). The exercise focused on engaging with ChatGPT through carefully constructed prompts, guiding students through a process that tied directly into topics previously covered in their courses. The objective was to familiarize students with AI, encouraging them to critically evaluate the information provided by ChatGPT in the context of their studies.

The core of the activity involved a worksheet that led students step-by-step in their interaction with ChatGPT. This worksheet prompted students to ask the AI questions related to their field of study, whether it be aspects of criminal justice or elements of forensic science. For instance, criminal justice students explored the implications of AI driven automation, while forensic science students examined AI's take on forensic analysis techniques. Throughout the activity, students were expected to critically assess the responses from ChatGPT, focusing on the accuracy and trustworthiness of the AI-generated information. This approach encouraged students to apply their academic knowledge to judge the reliability of AI responses, promoting discussions on the potential biases and ethical issues associated with AI technologies.

The activity concluded with students synthesizing their findings about the reliability of the information provided by ChatGPT. Through their assigned roles, students collaborated to highlight their examination of the AI's responses, its accuracy, and relevance to their subjects. This final step was crucial for deepening students' engagement with the content and for sparking discussion on the use of AI in criminal justice and forensic science. By participating in this guided inquiry, students not only expanded their knowledge of course content but also developed a more nuanced understanding of AI's role and reliability in their future professional fields. The activity emphasized the importance of critical thinking and ethical considerations when interacting with AI, aimed toward better preparing students to navigate the complexities of technology in their disciplines.

Student Engagement with POGIL Modules

Criminal Justice

There were 44 students in the CJ course, across two sections (20 in the face-to-face section and 23 in the online section), with pre- and post-ChaptGPT module data. Sixty-six percent of the students were female, 27 percent were male, 2 percent were non-binary, and 5 percent preferred not to answer. Students were asked about their racial identity. Multiple responses were permitted. Sixty-eight percent of the students were Black, 9 percent were White, 14 percent were Hispanic or Latino(a), 7 percent were American Indian or Alaskan Native, 2 percent were another race, and 7 percent preferred not to answer. Students were spread across class levels (See Table 1).

Class Level	Percent of Participants
High School Junior	2
High School Senior	0
College Freshman	0
College Sophomore	9
College Junior	32
College Senior	5
Did not answer	2

Table 1. Class level distribution of participating students in criminal justice class

Nearly all of the students had declared a major in CJ. Over a quarter are first generation college students. A little over half had taken a course in computer science, but only 11 percent have taken a course where they had learned something about AI. Before the course, 63 percent of students hoped to take courses in AI in the future.

Forensic Science

There were 20 students in the FS course, across two sections (20 in the face-to-face section and 23 in the online section), with pre- and post-ChaptGPT module data. Seventy percent of the students were female, 20 percent were male, and 10 percent were non-binary. Students were asked about their racial identity. Multiple responses were permitted. Sixty-five percent of the students were Black, 25 percent were White, and 25 percent were Hispanic or Latino(a). All students were college seniors, some in their fifth year, who were majoring in FS.

Forty percent are first generation college students. A little under half had taken a course in computer science, but only 20 percent have taken a course where they had learned something about AI. Before the course, 60 percent of students hoped to take courses in AI in the future.

Process and Procedures

The research team set aside time at a regularly scheduled meeting, creating a shared document with the survey questions or email chains to make sure experts from different disciplines had an opportunity to contribute to the module design. Together, the following preparatory activities were performed. The first activity was related to creating a concept map for the materials reflecting the newest advances in AI. The second was the study of use cases of the ChatGPT incorporating both productive use and limitations of ChatGPT in the selected domain areas. The third was a template of POGIL modules as an effective group-based learning technique for these use cases. During this process, the external evaluators offered feedback and perspective using the DBR approach to inform the development of the first iteration of the modules.

Next, these modules were tested in courses in CS, CJ, and FS. In accordance with the DBR approach, this testing involved a number of data collection points, followed by analysis and reflection. These data collection points included (1) the administration of a pre/post student assessment, and (2) focus groups with students

The results of these findings were shared with the project team. Then, (4) through a formal reflection session, the project team shared and discussed the findings and their learning, which informed the second iteration of the materials.

Data Collection

Both qualitative and quantitative data were collected as part of the DBR process.

Student Survey

Before and after the module, students were administered a survey. The 34-item survey assessment was comprised primarily of close-ended Likert-style questions, with items related to socio-cognitive outcomes known in the literature to correlate with interest and pursuit of STEM careers; student perceptions of AI; and demographic questions. The socio-cognitive items were drawn from existing validated measures grounded in Social-Cognitive Career Theory. The student perceptions of AI items were developed by the evaluation team with input from the FSU faculty AI experts.

Student Focus Group

Five student focus groups were conducted with students participating in CS, CJ, and FS courses who experienced the modules. All students in the courses were invited to participate in the focus groups by their faculty instructors, though the instructors did not attend the focus group session. A total 35 of students participated.

Project Team Reflection Exercise

All four members of the Project team met virtually, with one of the lead evaluators participating in a reflection exercise which resulted in the production of a collaboratively developed reflection map summarizing the team members' key takeaways and insights.

Findings

Student Survey

To assess the impact of the Project, a series of paired-samples t-tests were conducted. In this kind of analysis, individual growth from pre-to-post time points is examined, meaning that only those individuals with data at both time points are included in the analysis. To see if the observed differences in composite scores from the survey were statistically significant (and thus, highly unlikely to be due to random chance), paired-samples t-tests were conducted; one for each composite. These analyses were performed with three groups of students, those in each of these courses. Statistically significant results are detailed in another manuscript forthcoming. In sum, findings from the student survey suggest that students in the CJ course walked away from the course experience with greater knowledge and awareness of the process, impacts, and applications of AI and more awareness of AI-related careers. Those in CS also gained AI knowledge and increased their awareness of applications

of AI. Statistically significant gains were not observed for FS students.

Student Focus Groups

Within the qualitative analysis of the student focus groups several themes emerged:

POGIL Structured Group Activities Viewed Overwhelmingly Positively

A consistent theme that emerged across all the focus groups conducted was the effectiveness of the group work structure at promoting conceptual understanding and reinforcing social interactions. Participants found the group work activity on ChatGPT to be effective in helping them understand the concept better. One participant stated,

> *We actually got to work as a group and get an understanding of it. And I think that's what really helped because when you sit behind a computer and you're doing a lot of coursework and reading from a book and you're not having an interaction with people, it's not easy for you to remember that stuff.*

In all cases, the participants offered that the group activity structure that was used was a welcome departure from the usual mode of interaction and instruction in the course.

Some Benefits Reported for Departing from the POGIL Format

While the feedback was overwhelmingly positive about the experience of engaging in the POGIL structured group activity, there was some feedback that for the specific task that was assigned, departing from the POGIL roles ultimately enhanced the overall experience. The departure was by teams where instead of only one person interacting with the ChatGPT interface, multiple members of the group began directly engaging. The focus group participants who experienced this situation indicated that there were a lot of insights and issues that came to light once the group started comparing the different answers that were being obtained to the same questions and as multiple people started to create their own prompts.

The Introductory Video was Not Widely Watched

The students who attempted to watch the video were not able to maintain their engagement with it provided reasons that fell into two areas: (1) a lack of interest in the content or (2) the content was perceived as too difficult to grasp.

Students were Vulnerable to Misunderstanding the Key Takeaways

Many students mistakenly concluded that the activity was designed to introduce them to ChatGPT rather than to help them become more familiar with the concept of trustworthiness of AI.

Project Team Reflection

During the reflection exercise, there was full participation across attendees, who input entries in all categories of the reflection mapping exercise. Additionally, the group engaged in meaningful discussion around several topics, including the progress made at being able to make AI content accessible and relevant for non-CS audiences, the value of modeling for students strategies for critically examining AI outputs, the increasing relevance of exposing non CS-students to AI applications, and some of the shortfalls of the technology in terms of connectivity and amount of time required to allow students to fully engage in the activities.

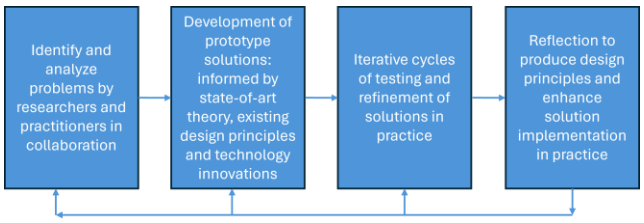

Figure 1: Design-based Research Process

Conclusion

This project set out to add to the growing body of knowledge on how to motivate the study of AI, how to prepare students for the modern-day workplace where both AI skills and domain knowledge are important, and how to train informed and socially responsible creators and users of AI. A Design-Based Research approach was utilized to ensure that the educational materials create rich student experiences, leveraged best practices in pedagogy, generated the desired impacts, and could be scaled. In the first DBR cycle, the project team and external evaluators collected and analyzed data around an initial implementation within CS and non-CS courses.

The general findings suggested the following:

- Students' exposure to science fiction depictions of AI, coupled with the sensationalist portrayals in contemporary media, have led to firmly rooted misconceptions about AI capabilities.

- Students held inaccurate perceptions of the prevalence of AI applications already in use within their chosen fields.
- The early activities aimed at increasing students' awareness of AI trustworthiness and ethical usage have the potential to raise alarm and anxiety among students, with students most commonly voicing their fear of being "replaced by AI".

The process of addressing these findings is a multi-phase process. We made a significant improvement during the development of a second iteration of the materials that addressed the challenges that surfaced and were better aligned with the goals of the project.

The choice of a new area for AI application was focused on where its trustworthiness is most vulnerable. The study area of Police Stops was selected with attributes such as Police Using Force, to make students more engaging, more emotionally involved, and appreciate the importance of strategies they were using to examine the outputs from an AI tool. A different, more established, and predictable AI tool was used to avoid differences of versions and obtain more controllable results for experiments. More specifically, the Decision Trees tool was used for data and trustworthiness analysis.

The better integration of content of the introductory video with content of POGIL interactions. More specifically, the Decision Trees example with basic operational capability was used in the video, and similar capabilities were tested by students during POGIL interactions. Therefore, the video activity was to provide students with an opportunity to learn about a new AI tool and POGIL interactions to examine how well it performed in providing information from their discipline of study. As a result, students were better positioned to engage in the POGIL activity structured to extend their knowledge of AI tool and afford them opportunities further exposing some of the limitations of AI.

Additionally, in light of this early learning, the team is adding a dedicated research effort to identify commonly held misconceptions and more directly address student anxiety around the proliferation of AI. The DBR approach will continue to inform the enhancement and adaptation of the project-created learning materials and instructional approach.

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