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Using hackathons to enhance university-level water curriculum for students in minority communities

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Abstract

This article illustrates the potential for hackathons to serve as an innovative educational tool in addressing the underrepresentation of minority communities in science, technology, engineering, and mathematics (STEM) fields. Using Merced, California—a region recognised for its agricultural economy, socioeconomic disparities, and diverse population—as a case study, this work explored how hackathons focused on water-related and agricultural challenges help align the region's agricultural needs with the current workforce's skills. Hackathons have the potential to augment university-level water curricula, bridging traditional disciplinary approaches and strengthening the local workforce. Workshops within these hackathons are an opportunity to introduce new skills and techniques, fostering a problem-solving environment. Finally, the authors provided recommendations, based on participant survey data, to enhance future hackathons, focusing on increasing engagement among minority groups, contributing to a more inclusive and diverse STEM workforce.

Keywords: hackathons; inclusivity; minority communities; STEM.

Introduction

California’s Central Valley contributes '8% of U.S. agricultural output (by value)' and grows about US$17 billion worth of produce (USGS California Water Science Center, no date). However, it is historically one of the most persistently poor and unequal regions in the U.S. and experiences one of the highest unemployment rates in California (Bohn, 2022). These

issues disproportionately affect minority communities, which make up a significant portion of the Central Valley's population and are essential to its agricultural workforce, yet remain underrepresented in high-paying science, technology, engineering, and mathematics (STEM) fields (Kimberlin and Anderson, 2022). With the advancement of artificial intelligence and automated sensors, there is an expanding opportunity to incorporate technology into day-to-day farm operations and engage underrepresented groups in the region with relevant STEM pathways (West, 2023). This article analyses three hackathons focused on agriculture and water issues as opportunities for university students to learn relevant skills to be successful in these positions. It examines their ability to improve university-level water education and promote awareness of agriculture and the water sector careers among students. The authors discuss the advantages and disadvantages of each hackathon's approach and provide recommendations for successful, inclusive programming.

Teams comprised individuals from Secure Water Future (SWF) – a "collaborative of investigators from across the semi-arid western US aiming to improve agricultural and environmental water resilience" (Secure Water Future, 2023) – together with members from AgAID whose "mission is to build and foster partnerships between AI and Ag[riculture] communities and create a transdisciplinary ecosystem for technology innovation and knowledge transfer" (AgAID, no date). Both teams worked with team members at the University of California, Merced, utilising shared resources to collectively answer pressing questions about water, agriculture, and the future of technology.

University of California, Merced, the newest institution in the UC system, draws its student body from historically underrepresented groups. According to institutional data illustrated in Figure 1, in fall 2023, 65 percent of undergraduate students were first-generation, and 54 percent were Hispanic (*Facts, Rankings & Accolades*, no date). Additionally, as shown in Figure 2, 60 percent of undergraduate students enrolled in fall 2023 were eligible for Pell Grant funding (Johansen, 2023), a grant reserved for students with severe financial need (*Federal Pell Grants*, no date). This article explores the impact of educational programming for university students in a historically underrepresented region to enhance their understanding of water and agriculture. While both the SWF and AgAID teams comprised investigators from many states, this article focuses on the impact of this programming at UC Merced due to the distinct demographic makeup of the students and the need for workforce development in the region.

Figure 1. UC Merced Student Demographics – Fall 2023.

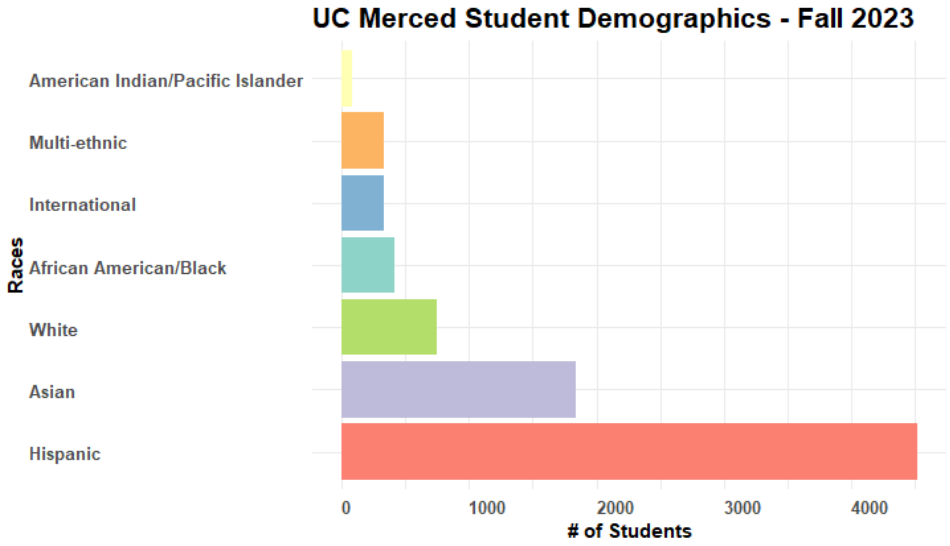
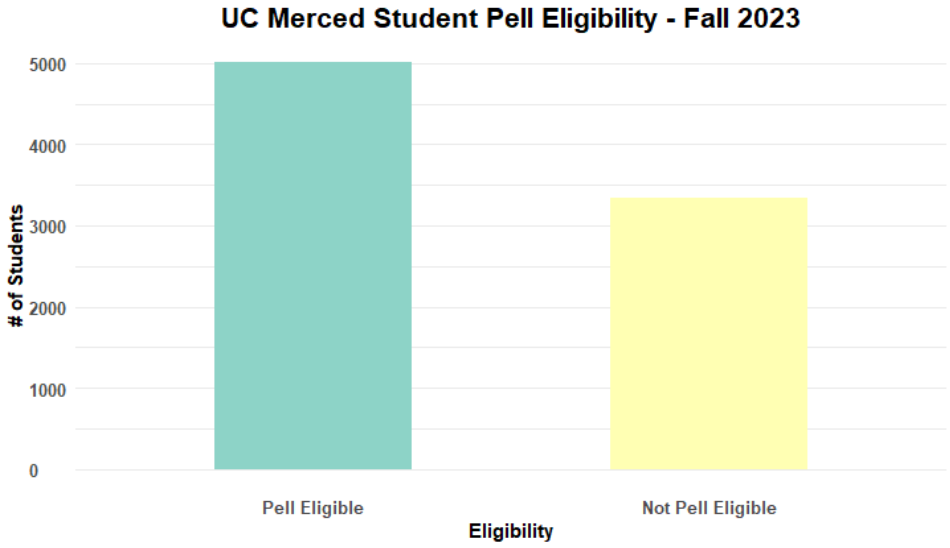


Figure 2. UC Merced Student Pell Eligibility – Fall 2023 (Johansen, 2023).



Hackathons

Hackathons are events where participants tackle challenges by creating innovative solutions individually or in small teams over a moderately short period (Lara and Lockwood, 2016). Hackathon durations vary, ranging from a single day to several days. These events can be virtual, in-person, or hybrid (a combination of both virtual and in-person). Although the solutions created in hackathons may require technical skills, participants are not required to have a computer science background. Hackathons allow

participants to learn new skills and gain knowledge to construct creative solutions to pressing issues.

The benefits of hackathons

Hackathons are a project-based learning (PBL) opportunity. PBL is an educational approach that engages students in the 'investigation of authentic problems' by working on projects that allow them to gain hands-on experience (Blumenfeld et al., 1991, p.369). PBL enables students to integrate existing knowledge and past experiences with new learning, fostering deep domain-specific knowledge and critical thinking strategies to apply to real-world problems. Hackathons present challenges that mirror real-life scenarios, facilitating the application of skills generally not taught in the classroom (Blumenfeld et al., 1991).

Projects can enhance metacognition, the process of utilising awareness of one's cognitive abilities and knowledge of appropriate strategies for the task at hand while planning, monitoring progress, and evaluating solutions (Cambridge International Education Teaching and Learning Team, n.d.). This improvement of metacognition abilities is evident as participants iteratively improve their solutions to deliver the final product.

Data literacy is increasingly becoming a crucial skill, especially now that making data-driven decisions has become a ubiquitous thing in the workplace (Provost and Fawcett, 2013). According to Gunter (2007), individuals must be able to analyse, manipulate, and interpret data to develop data literacy. Consequently, enhancing data literacy requires improving problem-solving skills through opportunities for critical thinking (Gunter, 2007). Hackathons featuring tracks dedicated to data-centric projects give participants exposure to working with real-world data and its challenges, such as reliability, incorrect data, and unused data fields (Anslow et al., 2016).

Effective communication and the ability to collaborate with individuals from varying fields are highly regarded skills in the workforce (Ferns et al., 2021). Like other PBL opportunities, hackathons provide a social component not offered by traditional learning techniques (Lara and Lockwood, 2016). Therefore, hackathons simulate the experience of professionally working in a team. By sharing expertise and learning from one another,

participants can enhance their communication and collaboration skills and 'be more open-minded to different perspectives' in interdisciplinary teams (Ferns et al., 2021, p.S221).

Purpose

According to Dale, Robinson and Edwards (2017), most incoming freshmen at Oklahoma State University did not possess passing knowledge of basic agricultural concepts. Though a career in agriculture may not interest all, agriculture products are essential to everyone. Consequently, there is a need for universities to incorporate educational components that allow students to learn and understand the significance of agriculture (Dale, Robinson and Edwards, 2017, p.7). While there are vocational agricultural programmes, minority students attending urban schools have the most limited access to these programs (National Research Council, 1988).

Many minorities face significant barriers to accessing opportunities that foster social mobility, often due to systemic inequalities in education and economic resources (Haveman and Smeeding, 2006). This lack of access can prevent minority students from gaining the knowledge and skills needed for careers that offer economic advancement and stability. Hackathons can offer free, hands-on upskilling opportunities where participants can acquire the technical and interpersonal skills that are highly valued in today's job market (Covic and Manojlovic, 2019). Additionally, hackathons can provide participants with domain-specific knowledge in fields of interest, exposing them to a range of career pathways. Beyond job market skills, hackathons can also serve as platforms for sustainability education, encouraging innovation and collaboration on projects that address environmental challenges (Paul, 2020). By adapting this format to focus on agriculture, hackathons can help raise awareness in underrepresented regions about the potential of technology to solve industry-specific challenges.

Hackathon data collection

The following data was collected from three hackathons:

- AgAID D1g1tal AgAth0n (2020)

- AgAID Digital AgAth0n (2023)
- Secure Water Future Water Hack Challenge (2023)

All survey data was provided anonymously, but with informed consent, shortly after the event ended and all photographic materials were collected with explicit permission from participants. Non-participation or refusal to provide images did not affect an individual's opportunity to participate in any activities.

AgAID D1g1tal AgAth0ns

The first D1g1tal AgAth0n was a five-day hackathon in October 2020 held virtually due to COVID-19. This hackathon aimed to teach participants new cloud computing skills and use sensor data or satellite/drone imagery to 'deliver agriculture-focused insights' (innov8.ag, 2020'). The D1g1tal AgAth0n convincingly showcased the ability of hackathons to foster cross-disciplinary participation through the broad range of participant diversity, with participants belonging to over 14 departments across four colleges and five WSU campuses (innov8.ag, 2020). The hackathon enabled participants to work in interdisciplinary teams, leveraging each other's strengths. Given the success of the first iteration of the hackathon, the AgAID team sought to expand the D1g1tal AgAth0n to partner universities, using a hybrid format to accommodate participants concerned about COVID-19.

In January 2023, AgAID hosted the Digital AgAth0n, lasting three days. The AgAth0n was open to both undergraduate and graduate students and had over 160 participants. Prior to the event, students filled out a form detailing their technical skills and knowledge which the organising committee used to assemble teams with balanced skill sets. Challenge statements are crucial in hackathons because they identify a problem in which participants can create a solution. AgAth0n participants could select either the Labor or Water Challenge. The AgAID team provided written descriptions and videos that presented domain-specific knowledge to increase the quality of submissions. The Labor Challenge asked participants to create a system to count the number of apples in an image. A robot could use the solutions that participants came up with to pick apples from trees. The Water Challenge asked participants to develop and apply models to forecast cumulative precipitation for the Sacramento basin in Northern California using geospatial data (*Digital*

AgAth0n 2023, no date). Having more accurate forecasts would allow water managers, growers, and other relevant parties to make better, more informed decisions surrounding water.

Post-event analysis

The organising team conducted a participant survey to assess the hackathon's impact on students' technical skills, knowledge of agriculture issues, and to gather additional feedback. Out of 54 survey participants, 57.4% indicated they "agree" or "strongly agree" that they gained a better understanding of how to use cloud computing resources. Although Microsoft Teams workshops were offered, many participants expressed that they would have rather had workshops about how to set up and use Azure, a cloud computing platform that offers computing resources and services accessible over the internet, at least a week before the AgAth0n (*What Is Cloud Computing?* no date). Despite having dedicated support for Azure-related issues, the event's more than 160 participants resulted in slow response times, leading some teams to spend significant time troubleshooting Azure rather than focusing on their projects. Although learning to self-navigate complicated issues is part of the hackathon experience, having dedicated help for virtual participants and each in-person site would have facilitated more efficient troubleshooting and perhaps a higher percentage of improved comprehension in utilising cloud computing resources. On the other hand, 87% of respondents reported they “agree” or “strongly agree” that they gained a better understanding of how computer science and artificial intelligence can address agricultural problems. Creating detailed videos allowed participants to gain deeper insight into the real-world implications of the problems they were working on rather than just sharing the problem description.

While the hybrid experience allowed participants to join wherever they were most comfortable, it created different experiences for in-person and online participants. Those who attended in person had ready access to mentors, organisers, and other participants while online participants communicated through Microsoft Teams and email. The hybrid approach made it harder for the teams to work as cohesively as possible. A reflection collected from a participant at the conclusion of the AgAth0n detailed how they leveraged this experience to enhance their communication and collaboration skills:

> [O]ur largest challenge was connecting in the beginning without being...in person. [I]t put my communication skills to the test and strengthened them immensely. I now have a better picture of what communication skills I need to better develop in collaborative environments. It has taught me how to better adapt (anonymous participant).

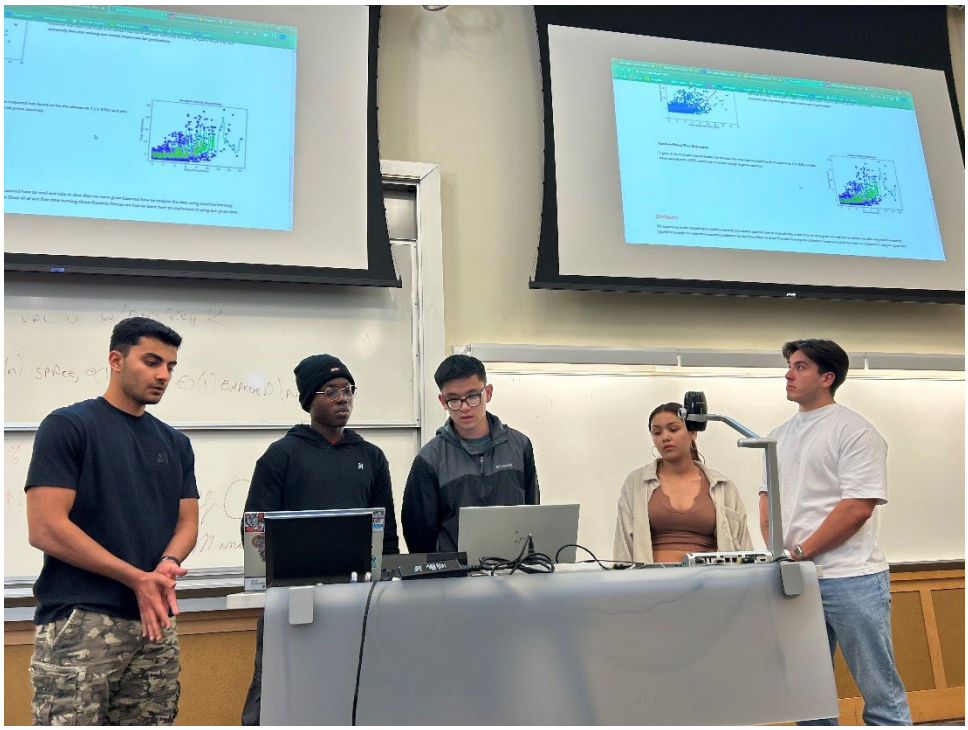
While the AgAth0n was widely considered a success, valuable lessons can still be taken away to improve future events. The feedback received from AgAth0n participants substantially impacted the design and approach of the SWF Water Hack Challenge.

SWF Water Hack Challenge

Secure Water Future held the Water Hack Challenge (WHC), an in-person three-day hackathon, at UC Merced, in April 2023. The WHC was open to undergraduate and graduate students from regional institutions. The in-person format was chosen to support one of the hackathon's primary goals: providing Central Valley students with a platform to collaboratively develop innovative solutions for prevalent water-related challenges and to build connections within the local academic community.

The three challenge tracks corresponded to a phase of the water cycle: Liquid-Flood, Solid-Snow, and Gas-Evapotranspiration. The Liquid-Flood Challenge prompted participants to create a model to determine flood risk in Merced, California, or produce a visual representation that aids users in understanding the certainty and trajectory of change in climate models using data from the 2023 Bear Creek Flood (see Figure 3). The Solid-Snow Challenge encouraged participants to leverage their data analysis and predictive modelling skills to determine the reliability of automated snow-measuring data. The Gas-Evapotranspiration (ET) challenge asked participants to create a predictive model to estimate the 'remaining ET time series for the rest of the water year', develop a predictive model for crop classification, or construct an interactive tool that enables water managers to view total usage within provided regional polygons easily (*Secure Water Future Water Hack Challenge*, no date, p.11). Since the WHC aimed to provide participants with opportunities to strengthen their data literacy skills, each challenge was accompanied by relevant real-world data.

Figure 3. Water Hack Challenge participants presenting their project.



Seven mentors provided expertise in at least one of the following categories: technical skills, water domain knowledge, and collaboration skills. All the mentors were physically present at the WHC, allowing participants to ask questions in person (see Figure 4). Although participants could submit questions online, they generally took advantage of face-to-face interaction to seek clarification or guidance on their projects.

During the hackathon, more than 75 participants had the opportunity to attend six undergraduate-led workshops to expand their technical and collaboration skills. The workshops at the WHC allowed students to learn about collaboration and technical skills, including mobile application development and user interface/user experience design, that they could apply to their projects. Some of the workshop leaders had previous experience at hackathons and gave their advice about how to make the most of the opportunity.

Figure 4. Water Hack Challenge mentoring.

Event analysis

A pre-event survey revealed that participants rated their programming experience 2.48 out of 5 and their machine learning experience of 1.43 out of 5 on average. Additionally, the survey showed that more than 30% of participants were not computer science majors. This showcases the ability of hackathons to bridge disciplines and get people with varying skillsets to work on problems.

Numerous aspects of the WHC contributed to its success as a meaningful participant learning experience. The in-person format permitted face-to-face collaboration, which allowed participants to build genuine relationships with teammates. This was also a unique opportunity for students to meet their Central Valley peers and network with one another, expanding their personal and professional circles. Having the mentors physically at the hackathon gave participants the support and expertise they needed in real time. The workshops offered during the WHC provided valuable learning opportunities where students could acquire practical skills that can be applied in real-world situations.

Throughout the hackathon, participants showcased data literacy and critical thinking skills. One of the teams that tackled the Gas-Evapotranspiration challenge successfully processed and analysed satellite imagery, which they fed to a machine learning model they developed to predict crop types in various fields. Despite the short timeline, they delivered a functional solution and identified key areas of improvement in regards to the accuracy of their model and overall completeness of the project.

Although the in-person format of the hackathon offered several benefits, it posed challenges for students outside of Merced due to long commutes, leading to some dropouts and reduced participation. The requirement for participants to dedicate an entire weekend made attending the event more challenging, especially for students with additional responsibilities.

Recommendations

To facilitate success, organisers should provide domain-specific knowledge and technical workshops before or towards the beginning of the hackathon. Mentorship is crucial to ensuring that participants feel supported throughout the hackathon. Since participating in a hackathon may seem intimidating, highlighting that people from all backgrounds and levels of experience are welcome can encourage participation. As seen with the 2023 Digital AgAth0n, women and first-generation students had low participation rates. Welcoming diverse individuals to take on leadership positions sends a message to participants that these events are inclusive with relatable role models (Holoien, 2013; Paganini and Gama, 2020). While these are targeted recommendations for organising an inclusive, efficient hackathon, organisers should exercise prudent discretion to consider participants' needs.

Conclusion

There is potential for minority communities to contribute towards a more diverse STEM workforce by enhancing their technical skills. As a PBL opportunity, hackathons have successfully improved students' data literacy and problem-solving skills. Therefore, it is crucial to facilitate hackathons in regions with historically underrepresented communities, such as California's Central Valley, so that individuals belonging to minority groups have

access to opportunities where they can elevate their skillsets and expand their networks. The availability of mentorship, workshops, and applicable domain-specific knowledge are critical factors to setting students up for success in a hackathon. By ensuring that hackathons are accessible and well-supported, students belonging to minority communities are empowered to drive innovation and diversity in the STEM workforce.

Future work

Further research is essential to clarify the long-term educational impact of hackathons in agriculture and beyond. Studies could explore whether hackathons lead to lasting skill retention and enhance problem-solving abilities or primarily serve as short-term, intensive learning experiences. Additionally, examining the adaptability of the hackathon format in other disciplines, like social sciences and the arts, could highlight its broader educational benefits. Longitudinal studies would be especially valuable for determining if participants continue to apply these skills over time, thereby establishing hackathons as sustainable educational tools. The research on hackathons as educational tools remains in its early stages, and further studies are needed to fully assess their impact on student achievement.

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