

# Shaping AI Interest in Rural Middle Schools with Unplugged Learning: Gender Differences and Teacher Insights

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## Abstract

Adoption of artificial intelligence (AI) is at an inflection point. With daily use of AI escalating due to widely available software tools, educators, researchers, and policymakers must adapt swiftly to changing educational needs. While think tanks and Big Tech companies often promote the notion that AI serves as a powerful tool for democratizing access to knowledge and opportunities, our work in rural communities underscores the disparity in access to AI education and related opportunities. In this paper, we report on our experience introducing foundational AI concepts to rural middle school students using an unplugged game-based learning activity. By providing engaging learning experiences to rural populations, we hope to broaden interest in and understanding of AI technologies. To this end, we conducted a classroom study in which two middle school teachers implemented our unplugged AI learning activity with their students. Analyzing survey data from 60 of the participating students, we explore the impact of the activity on their interest in AI, their conceptual understanding, and examine potential gender differences. Additionally, we share insights from the teachers who participated in our professional development sessions in preparation for the classroom implementations.

## Introduction

The remarkable growth in services and industries reliant on skills in computer science (CS) and artificial intelligence (AI) has underscored the need to ensure today's youth acquire these critical proficiencies, and highlighted disparities in students' access to related learning opportunities. Significant strides have been made in the United States to formalize expectations around CS, with 42 states adopting K-12 computer science standards and 30 states developing specific plans for bringing CS education to their students (Code.org 2023). Although expectations focused on learning AI are less formalized, 11 states have provided guidelines and best practices on AI to school districts, and three states have established AI curriculum standards or courses as of July 2024 (All4Ed 2024). Although this is notable progress, a different picture emerges when we examine overall efforts to bring CS and AI education to students, namely in terms of access, training, and opportunities aimed at rural populations.

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North Carolina is home to the second largest rural student population in the United States and is ranked as one of the top priority states in terms of addressing rural education needs, according to the National Rural Education Association (Showalter et al. 2023). Of North Carolina's 100 counties, 80 are identified as rural and they serve over 500,000 K-12 students, more than half of whom are of color, live in low wealth communities, and attend under-performing schools where there are fewer opportunities for learning via innovative instructional approaches (Showalter et al. 2019).

Our work aims to help address the gap in AI learning opportunities in rural communities across North Carolina. We have designed and iteratively refined a set of playful plugged and unplugged learning activities that introduce foundational AI concepts to middle school students (Goslen et al. 2024; Lim et al. 2024). One of our unplugged activities is a game-based learning activity in the form of a card game, called *Guess Whose Face*, that reinforces key insights from *Representation and Reasoning*—one of AI4K12's Five Big Ideas in AI (Touretzky et al. 2019).

The game highlights facial recognition, a technology that is utilized in a number of common applications, including being used to unlock smartphones and automatically identifying people in social media posts and photo applications. The extensive use of facial recognition makes it a recognizable and engaging tool for students, with the potential to serve as an effective way to introduce AI concepts to them. Following a set of refinements from piloting the game, we implemented the unplugged learning activity in the classrooms of two rural middle school teachers, reaching approximately 90 students. In this paper, we provide an overview of the game, as well as report on the professional development offered to our partner teachers, the classroom implementations, and our findings.

## Related Work

### K-12 AI Education

AI education in K-12 schools has recently gained momentum, yet its implementation varies significantly across grades, genders, and geographical regions, paralleling the uneven distribution observed in computer science education (Code.org 2023). This disparity results in diverse levels of exposure to AI learning among young students nation-

wide. Efforts to establish guidelines for AI education have grown in recent years (Touretzky et al. 2019), accompanied by efforts to explore AI learning progressions (Grover 2024; Touretzky et al. 2019; Wang and Lester 2023b). Emerging research is investigating effective strategies for teaching advanced AI concepts to young students (Choi and Park 2021; Lee et al. 2021; Shamir and Levin 2020), especially for those historically underserved in STEM (Goslen et al. 2024; Thomas et al. 2024; Williams, Alghowinem, and Breazeal 2024).

The rapid adoption of AI in K-12 settings underscores the necessity of equipping today's students with the skills and conceptual understanding to thrive in a future where AI will likely influence many aspects of their life (Wang and Lester 2023b; Walter 2024; Yim and Su 2024). Furthermore, AI education offers numerous potential advantages, including the enhancement of creative thinking and the fostering of motivation among K-12 students (Walter 2024; Wang et al. 2023). This has led to a surge in scholarly efforts aimed at developing and refining effective methods for K-12 AI education (Wang et al. 2023).

The AI4K12 initiative has been at the forefront of shaping the educational landscape in response to this growing need. This initiative, sponsored by the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA), has been instrumental in developing national K-12 guidelines (Touretzky et al. 2019). These guidelines revolve around the "Five Big Ideas in AI," encompassing key areas: *Perception, Representation & Reasoning, Learning, Natural Interaction, and Societal Impact*. The initiative's approach is holistic, focusing on the technical aspects of AI and its broader implications on society and ethical considerations. By doing so, the AI4K12 initiative aims to provide a comprehensive framework for AI education that prepares students for future technological challenges and addresses the ethical and societal questions posed by these emerging technologies.

In line with these developments, the U.S. Department of Education has recently put forth valuable insights and recommendations regarding the implementation of AI in school settings. Their report, *Artificial Intelligence and the Future of Teaching and Learning: Insights and Recommendations*, highlights the growing importance of equipping students with a comprehensive understanding of AI technologies (Cardona et al. 2023). It emphasizes the importance of developing students' conceptual understanding of AI, given its widespread influence across various sectors. This governmental endorsement, as articulated in the Department of Education's report, further amplifies the call for an integrated approach to AI education in schools.

Moreover, there is an increasing focus on ensuring K-12 AI education is more inclusive and accessible. Recent research initiatives are exploring culturally responsive approaches to make AI learning experiences more relevant and engaging for students from diverse backgrounds (Eguchi, Okada, and Muto 2021; Samuel et al. 2023; Wang and Lester 2023a). This involves contextualizing AI education to align with students' cultural and social contexts, thereby enhancing their understanding and interest in the field (Eguchi,

Okada, and Muto 2021). Such efforts are crucial to ensuring that K-12 AI education is effective, equitable, and inclusive. These initiatives and research efforts significantly underscore the importance of K-12 AI education. They highlight the need for well-rounded, age-appropriate AI learning activities that can spark early interest and sustained engagement in AI among students. This approach is essential for preparing future generations to navigate a world increasingly influenced by AI technologies.

## Unplugged Learning Activities

Unplugged activities are not new to CS education; significant effort has been made to increase student interest in programming and computational thinking by making activities more engaging and accessible (Bell et al. 2009; Huang and Looi 2021). Characterized by their interactive and hands-on nature, unplugged activities offer several key benefits:

- *Low cost and accessibility*: Unplugged activities generally require minimal resources and are not dependent on specific digital devices or sophisticated technology. This aspect makes it particularly beneficial in a wide range of educational settings, including those with limited access to advanced technological resources, thereby democratizing the learning process and making AI education more accessible to a wider student population (Lin et al. 2024; Merino-Armero et al. 2022; Zhang et al. 2024).
- *Excitement and engagement*: Unplugged activities involve interactive tasks with tangible materials and physical manipulatives, which can significantly increase engagement, especially for students who may find traditional computer-based learning less engaging (Lin et al. 2024; Septiyanti, Shih, and Zakariyah 2020; Zhang et al. 2024). Unplugged activities spark curiosity and foster a more profound interest in the subject matter, making learning both enjoyable and effective.
- *Potential for conceptual understanding*: Besides being engaging, unplugged activities are beneficial in facilitating the comprehension of complex technological concepts (Lin et al. 2024; Saxena et al. 2020; Zhang et al. 2024). By simplifying these concepts into approachable activities, students can grasp high-level ideas before delving into more detailed, technical aspects. This foundational understanding is crucial for students, as it lays the groundwork for more advanced studies.

Unplugged learning activities that center AI concepts are a newer addition to the research landscape (Lindner, Seegerer, and Romeike 2019; Ma et al. 2023; Sabuncuoglu 2020; Song et al. 2024). These activities aim to demystify the potentially complex nature of AI by simulating how AI technologies work in ways novices can easily understand. The big idea of *Representation and Reasoning*, for example, focuses on how to represent information such that a machine can reason with the given information. This notion can be particularly difficult to understand. However, by introducing a physical, hands-on activity through 'unplugged' learning, students can grapple with this concept in a playful and more approachable way.

## Gender Differences

Computer science research is replete with studies of differences by gender, with most reporting that female students have lower confidence in and attitudes toward computer science (Beyer et al. 2003; Sáinz and López-Sáez 2010; Scott et al. 2023). Additional work has found that although female students trail their male counterparts in terms of computer science attitudes, they are just as competent (Berdousis and Kordaki 2015; Kemp, Wong, and Berry 2019). Others have critically examined gender differences and *how* computer science is taught. McAdams (2018) found that female students preferred game-based learning approaches and visual design, and Zdawczyk and Varma (2023) found that interesting challenges were often highly effective. Recent work suggest that female students are more engaged by unplugged activities than male students (Li et al. 2024). Most AI education research around gender occurs with students in high school or beyond. One notable exception is Kim and Kwon (2024) who found that tangible and collaborative work in AI learning effectively supports young female students. It is with this background research that we set out to investigate potential gender and other differences as students played *Guess Whose Face* in their classrooms.

## Context

### Game Design and Pilot Testing

Over the course of a year, our research team iteratively designed, developed, and refined an unplugged learning activity for middle school students that focuses on *Representation and Reasoning*. Initial designs utilized a board game format, as we assumed the structure and common features would be easily recognizable to students. Following early pilot testing with the board game, however, we shifted the format to a card game. Several small scale studies occurred with the card game format as we worked to refine the game, resulting in the current version *Guess Whose Face*.

*Guess Whose Face* is similar the popular game “Guess Who?”; however, instead of identifying a hidden character through a series of questions, players attempt to guess the character using facial features extracted on tracing paper. In brief, and as reported in detail elsewhere (Lim et al. 2024), *Guess Whose Face* features three difficulty levels (Figure 1), with two sets of face cards per level—one set for the drawer and one for the guesser(s). The drawer, working behind a barrier, selects a card from their deck for the guesser(s) to attempt to identify and places a sheet of tracing paper on top of it (Figure 2). The guesser(s) reference their comparable set of face cards on their side of the barrier, but these cards are smaller. Each guesser takes a turn spinning the spinner and reads out to the drawer the instructions on the spinner segment. The segments can direct the drawer to add a specific number of feature dots along a facial feature or to add noise dots, which complicate the guessing process. This action, of adding dots to the tracing paper, is analogous to feature extraction—representation phase. Once updated by the drawer, the guesser(s) are shown the current state of the tracing paper at each turn. Additionally, the spinner includes segments directing the guesser(s) to guess the character or

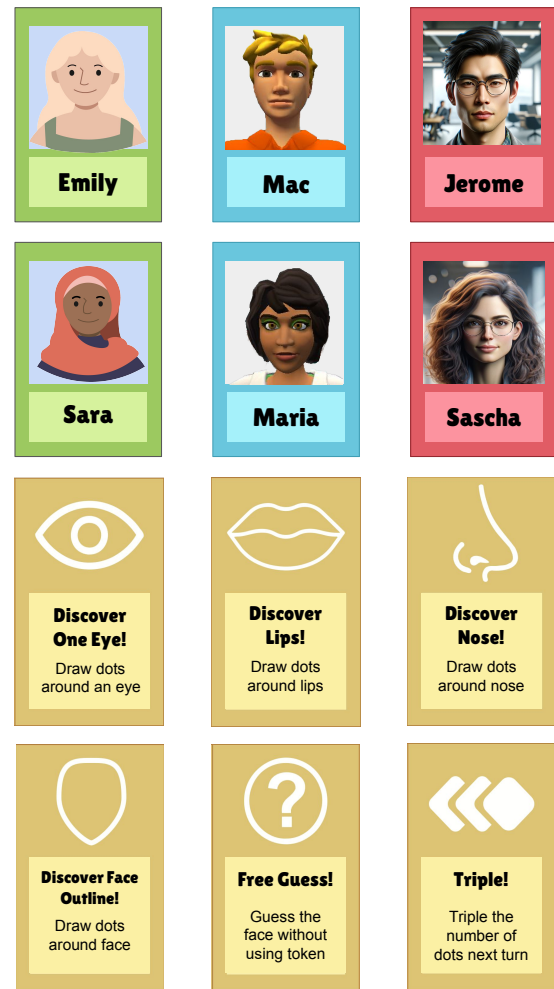


Figure 1: Top two rows show sample “Face Cards,” which are divided into three difficulty levels (green for easy, blue for medium, and red for hard). Bottom two rows illustrate example “Chance Cards.”

to draw a chance card (Figure 1). The chance cards include directions to double or triple the next spin (adding more feature or noise dots), take a guess for ‘free,’ or for the drawer to emphasize a single facial feature with dots. Free guesses allow the guesser(s) to pick a face card they believe the drawer is representing without giving up any of their three guessing tokens. The game continues until a guesser has correctly identified the character—reasoning phase—or they have run out of tokens. Students can then switch roles.

**Spinner.** The spinner determines the next action in the game, adding an element of unpredictability to gameplay. It is divided into different colors to help students visually connect the corresponding actions. Each guesser spins during their turn, providing a consistent structure to the game.

**Chance Cards.** Chance cards provide additional variability in how the game unfolds. They are drawn whenever guessers



Figure 2: Students playing *Guess Whose Face*. Student on the left is the *Guesser* and student on the right is the *Drawer*.

land on the spinner’s “Chance!” segment. The following lists the types of chance cards:

- *Discover a Facial Landmark*: Draw dots around the specified landmark (e.g., eyes, lips, nose, face outline) to reveal those facial features.
- *Free Guess*: Make a guess about the hidden identity without consuming one of the guesser’s available tokens.
- *Double / Triple*: Double or triple the number of feature or noise dots the drawer makes during their next turn.
- *Skip*: Pass the turn and move to the next player.

### Professional Development

Our research team held a day-long professional development (PD) session to introduce middle school teachers to foundational AI concepts as well as to the set of plugged and unplugged activities we have developed for use in their classrooms. Among other activities, as part of the professional development, teachers were presented a set of informational slides on the idea of *Representation and Reasoning* and then given the opportunity to play *Guess Whose Face*. Each teacher was provided access to the slide decks and sets of cards for use in their classrooms (Figure 3). Two teacher-led implementations were scheduled at the end of the professional development, with project staff planning on attending to observe the implementations.

### Study Implementations

The two implementations occurred over two days each. On the first day, the teachers provided students with access to



Figure 3: Teachers engaging in AI-focused PD activities.

the study assent form and set of pre-activity survey items, then used the slide decks they received during the PD session to provide students with the necessary background information on AI, engaging them in conversations around how and where the students see these technologies. On the second day, students were provided a brief overview of *Representation and Reasoning* and then played several rounds of *Guess Whose Face*, ending the session with the same set of survey items, now given as a post-study evaluation. The teacher participants taught at two different rural middle schools and both worked with academically or intellectually gifted students in 6th, 7th, and 8th grade. Teachers participated in a

post-implementation interview so that the project team could better understand their perspectives on implementing the activity and to seek feedback on recommendations for changes or requests for additional resources.

### Student Surveys

Due to the limited classroom time available for the implementations, a brief pre- and post-survey including attitudinal items based on Zhang et al.'s work (2023), which were answered using a 5-point Likert scale from *Strongly disagree* to *Strongly agree*, and conceptual understanding items, which provided multiple choice responses, was utilized. The survey included items such as "I will take a class about AI if it is offered in my school" to gauge interest in AI and items such as "How does AI figure out who someone is by looking at a photo of their face?" to measure knowledge about feature extraction and facial recognition.

### Teacher Interviews

Findings from the participating teachers' interviews centered around key factors that facilitated their implementation efforts, challenges they encountered, as well as their perceptions of student interest and learning.

**Resources and Support.** Both teachers emphasized the value of playing the game during the professional development session. Teacher 1: "I'm a hands-on learner and visual. So me doing the game actually helped and I really appreciated that." This hands-on experience allowed the teachers to familiarize themselves with the game's mechanics and objectives from a learner's perspective. Teacher 2: "When you just get the rules for a game there's so many things you would not think of, but having done it myself [helped]." Furthermore, both teachers shared that they played through the game again on their own prior to the classroom implementation to increase their confidence in the ability to support student gameplay. The instructional slides provided by the research team was an additional support resource, "I liked the intro slides for the game to make sure I'm saying the right verbiage and terminology." They both utilized the slides as an instructional tool to introduce the game to their students. Finally, although the teachers did not rely on members of the research team to implement the game in their classrooms, they appreciated having "experts in the room" to answer more complex student questions about AI and address any other potential issues that may have arisen.

**Implementation Challenges.** The teachers noted that the primary challenges to classroom implementation revolved around time constraints and the game's logistics rather than students' lack of conceptual understanding of the AI concepts. Both teachers cited a desire for more time to allow their students to fully engage with the game. They felt their 40 to 45 minute class period was insufficient for students to complete all three levels of the game, which limited the depth of the students' engagement and ability to fully explore the AI concepts. "My second class was able to move up to the second level where you've got the Disney characters where they all have similar facial features, so it makes it

a bit harder. I want to play again next week and get them to the third level. I remember it was hard for me," Teacher 2.

Both teachers also noted some confusion over some of the game's rules and logistics. In particular, students struggled with the purpose of the tokens to make a guess. One of the teachers also reported having to intervene with several of her students, who incorrectly assumed that the guesser's gameplay was over if they made an incorrect guess. However, the teachers were comfortable enough to make adaptations for their students in real-time to ensure they were still able to play and enjoy the game. Notably, both opted to remove the use of the tokens to simplify gameplay and one teacher let her students create their own guessing rules.

**Student Engagement and Learning.** The teacher interviews provided valuable insights regarding student outcomes from game use in the classroom. First, both teachers observed that their students were highly engaged and having fun while playing the game. Most importantly, the teachers noted an increase in their students' comprehension of the AI concepts addressed in the game. The teachers reported that their students had some prior surface level understanding that computers could recognize faces, but through the game, they gained deeper insights into how facial recognition works. Teacher 2: "They really understood how computers saw things differently now because [before] they just thought there was a picture of your face. They didn't realize it was different points. I did go over with them about the points and everything, but until they experienced it in the game, they did not get it." The teachers observed students correctly using and applying terms such as "feature extraction" and "noise" as they played the game with their peers. The teachers also noticed that the game sparked students' curiosity about AI as they asked thoughtful questions about the implications of facial recognition technology. For example, Teacher 2 explained how her class engaged in a discussion about how the technology responds to changes in someone's facial appearance. And Teacher 1 noted that some of her students were very interested in "the criminal side of things." This suggests that the game can be a segue into more complex AI concepts as students become more interested in learning about AI and its impacts on society.

### Student Outcomes

Approximately 90 students took part in the teacher-led classroom implementations using *Guess Whose Face*. Only 66 students completed both the pre and post surveys and six students were removed because of outlier behaviors (e.g., answering all questions with the same answer option). One student self-identified as non-binary, so for binary gender analysis, we focus our reporting on this subset of 59 students. Data were collected via Qualtrics and analyzed using Excel. Student attitude scores range from 3 to 15 (sum of scores for the three attitudinal items), while student knowledge scores range from 0 to 3 (sum of the three conceptual understanding items). A set of t-tests and ANOVA tests were conducted to analyze the data. To identify significant changes within the same group, a paired t-test was conducted. To identify significant differences between differ-

ent groups, an independent t-test and an ANOVA test were performed. These statistical tests aimed to identify significant differences in the students' attitudes towards AI and AI knowledge (learning gain), as measured from the pre-survey to the post-survey. We utilize the equation in Figure 4 to compute the normalized learning gain from each student's pre-post-survey scores. The results of this analysis, including the pre- and post-scores, p-values, learning gains, and effect sizes, are presented below.

$$c = \begin{cases} \frac{\text{post} - \text{pre}}{100 - \text{pre}} & \text{if post} > \text{pre} \\ \text{drop} & \text{if post} = \text{pre} = 100 \text{ or } 0 \\ 0 & \text{if post} = \text{pre} \\ \frac{\text{post} - \text{pre}}{\text{pre}} & \text{if post} < \text{pre} \end{cases}$$

Figure 4: Equation for normalized learning gain.

The AI attitudes among students who participated in the *Guess Whose Face* activity and completed all of the study materials increased from a pre-survey mean score of 11.15 (SD = 2.81) to a post-survey mean score of 11.58 (SD = 2.61). While the change was not statistically significant ( $p = .38$ ), it is worth noting that there was an increase. The average knowledge score increased from a pre-survey score of 2.01 (SD = 0.87) to a post-survey score of 2.18 (SD = 0.89), indicating a marginal trend towards statistical significance with a p-value of 0.09. While this suggests the *Guess Whose Face* activity may have led to an improvement in students' knowledge of AI, the effect did not reach a statistically significant threshold. However, with a learning gain of 0.20 (SD = 0.65) and an effect size of 0.17, the results hint at a positive educational impact, although one that might be considered subtle.

### Gender Differences

For male students ( $n = 31$ ), the attitude scores increased slightly from a pre-survey average of 11.35 (SD = 3.30) to a post-survey average of 11.41 (SD = 3.15), but this change was not statistically significant ( $p = 0.42$ ), with a negligible effect size of 0.03. In contrast, female students ( $n = 28$ ) showed a notable increase ( $p = 0.02$ ) in attitude scores from a pre-survey average of 11.00 (SD = 2.22) to a post-survey average of 11.75 (SD = 1.95), which was statistically significant and had a moderate effect size of 0.39. These results suggest that the *Guess Whose Face* activity had a positive impact on changing attitudes towards AI among female students.

For male students, conceptual understanding scores increased from a pre-survey average of 1.93 (SD = 0.85) to a post-survey average of 2.12 (SD = 0.95), though this change was not statistically significant ( $p = 0.16$ ). The normalized learning gain was 0.23 (SD = 0.68), with an effect size of 0.17. Female students saw their conceptual understanding scores rise from a pre-survey average of 2.07 (SD = 0.89) to a post-survey average of 2.25 (SD = 0.84), which also was not statistically significant ( $p = 0.12$ ). Their normalized learning gain was 0.19 (SD = 0.62), with an effect size

of 0.21. A t-test comparing the normalized learning gains between male and female students showed no statistically significant difference ( $p = 0.41$ ). Overall, the analysis based on gender suggests that while the *Guess Whose Face* activity had a significant positive impact on the change in attitudes towards AI among female students, the changes in AI conceptual understanding for both male and female students were not statistically significant.

### Grade Level Differences

Grade 6 students' ( $n = 17$ ) attitudes towards AI increased from a pre-survey mean of 11.41 (SD = 3.29) to a post-survey mean of 11.94 (SD = 3.13). However, this change was not statistically significant ( $p = 0.18$ ). An effect size of 0.22 suggests that some students in Grade 6 may have experienced a small positive shift in attitudes. For Grade 7 students ( $n = 17$ ), there was a significant increase in attitude scores ( $p = 0.03$ ) from a pre-survey mean of 11.23 (SD = 2.65) to a post-survey mean of 12.11 (SD = 2.08), with a moderate effect size of 0.46, indicating the *Guess Whose Face* activity had a significant and positive impact on their attitudes. In contrast, Grade 8 students ( $n = 26$ ) showed only a slight increase in attitude scores from a pre-survey mean of 10.92 (SD = 2.66) to a post-survey mean of 11.00 (SD = 2.54) ( $p = 0.39$ ), with a negligible effect size of 0.05, implying that the *Guess Whose Face* activity did not influence Grade 8 student attitudes.

The conceptual understanding scores of Grade 6 students slightly increased from a pre-survey mean of 2.11 (SD = 1.05) to a post-survey mean of 2.23 (SD = 1.03), yet this change was not statistically significant ( $p = 0.35$ ), and the normalized learning gain was 0.12 (SD = 0.80) with an effect size of only 0.09. Conversely, for Grade 7 students, the conceptual understanding scores increased ( $p = 0.10$ ) from a pre-survey mean of 2.05 (SD = 0.65) to 2.35 (SD = 0.78), placing this change at approaching statistical significance, with a normalized learning gain of 0.34 (0.66) and a larger effect size of 0.31. Grade 8 students' conceptual understanding scores rose ( $p = 0.23$ ) from a pre-survey mean of 1.92 (SD = 0.89) to a post-survey mean of 2.03 (SD = 0.87), not statistically significant, with a normalized learning gain of 0.13 (SD = 0.56) and an effect size of 0.14. This suggests that *Guess Whose Face* did not significantly impact students' AI conceptual understanding. However, considering the p-value on the threshold of significance for Grade 7, along with an effect size of 0.31, suggests the activity could be more effective for this grade level compared to others.

## Discussion, Limitations, and Takeaways

### Discussion

Female students demonstrated significant positive change in attitudes towards AI with a substantial effect size, indicating a significant impact of the activity on their perceptions of AI. While male students showed a marginal increase in attitude scores, this was not statistically significant. Conversely, changes in AI conceptual understanding did not show statistical significance for either gender, despite slight increases in scores. The investigation into the differences in changes

in attitude and conceptual understanding about AI across different grade levels, produced complex outcomes. While the *Guess Whose Face* activity appeared to positively influence Grade 7 students' attitudes towards AI, with a significant increase in attitude scores, its effect on AI conceptual understanding levels across all grades was not statistically significant. Grades 6 and 8 showed only slight and non-significant changes in attitude and conceptual understanding, respectively. Additionally, the analysis revealed no substantial differences in normalized learning gains among the different grades. These results indicate that while the *Guess Whose Face* activity has potential benefits, its impact varies by grade level, with Grade 7 students showing the most marked improvement. These outcomes underscore the variability in the impact of educational activities across different demographic groups and suggests the potential for tailored interventions to optimize learning outcomes.

### Limitations

Although we firmly believe this work contributes to the development of unplugged activities for K-12 AI education by providing detailed and iterative refinement processes and methods for evaluating the activity with respect to targeted AI concepts, we recognize several limitations. First, we worked with a smaller than ideal sample size, especially because of the number of students who did not complete the post-survey. Second, the students all came from two schools in the same school system and all received academically and/or intellectually gifted services, making the sample not fully representative of the broader middle-grade student population. Third, the duration of the activity and survey were brief, reducing the likelihood of seeing significant changes to student attitudes or learning.

### Conclusions and Takeaways

Findings from the teacher interviews highlight two key takeaways that provide important directions for moving our work forward. First, it highlights the essential role of providing teachers with scaffolding and support for implementing unplugged AI learning activities, such as *Guess Whose Face*, in the classroom. Both teachers underscored the utility of the hands-on practice session during the professional development, their follow-up practice, and the informational slides as critical for building their confidence to support student gameplay. These resources fostered a greater understanding of the game's mechanics and learning objectives. Furthermore, the teachers expressed that their comfort evolved throughout the school day with each subsequent class period. This growing confidence enabled them to sustain their students' engagement as they successfully navigated implementation challenges with impromptu adjustments tailored to their students' immediate needs. Additionally, as the day progressed each class period encountered more in-depth AI concepts by advancing to more levels than the one before it as teachers mastered game logistics.

Secondly, the teachers' observations of their students confirmed that the game served as an effective introductory activity to learning about *Representation and Reasoning* and significantly deepened their understanding of how facial

recognition technology works. The game sparked students' curiosity as they asked questions regarding more complex aspects of AI, such as its societal and ethical implications. This suggests that *Guess Whose Face* can not only be utilized as an effective resource to develop foundational knowledge around *Representation and Reasoning*, but that it can also be used as a segue into the other "Five Big Ideas in AI," such as *Societal Impact* (Touretzky et al. 2019). Recognizing this potential, our team is developing extension activities and teacher prompts that can follow student gameplay to guide discussions around AI's broader impacts.

Findings from the surveys highlight two key takeaways that support the need to refine our current work. First, survey data, across all the middle school participants, indicate that female students underwent a significant change in attitudes toward AI. We are acutely aware of the common gender disparities in computer science and AI, and were pleased to discover that our unplugged activity cultivated female students' interest in AI. We would be remiss if we did not consider the attitudes of all our of students, however. Engaging all students in ways that shift their attitudes toward the positive is important. That neither male nor female students demonstrated significant changes in conceptual understanding is concerning; however, we surmise the brief survey length and intervention period may have contributed to this lack of change. Longer studies that enable students to play through multiple rounds of the game at various difficulty levels may help address this finding.

Second, 7th grade students demonstrated significant changes in attitudes from pre to post activity. Although 6th and 8th grade students showed small increases, we would prefer to see significant changes, demonstrating all students found value in AI. Similar to above, none of the grades demonstrated any significant change in conceptual understanding from pre to post. This is not surprising given the brevity of the activity. Pairing unplugged and plugged activities on *Representation and Reasoning* over several learning sessions may improve this finding.

Future efforts for this work include conducting more extensive studies with larger groups of students to make further improvements to the activity as well as to utilize revised pre and post survey questionnaires. Potential future work for the field of AI education includes the creation of additional unplugged activities and a range of resources for both students and teachers that emphasize the ethical implications of AI. This continuation of research will also contribute to the broader field of K-12 AI education by providing insights into the integration of innovative tools and ethical considerations into learning environments.

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