

Briefing Paper: Collaborative: RAPID: DRL AI: Integrating Culturally Relevant Project-based AI-integrated Learning (CRPAIL) in high-school STEM classes

July 31, 2024

Prepared by

Shenghua Zha, Ph.D.

College of Education and Professional Studies, University of South Alabama

Woei Hung, Ph.D.

College of Education and Human Development, University of North Dakota

Lujie Karen Chen, Ph.D.

College of Engineering and Information Technology, University of Maryland Baltimore County

Na Gong, Ph.D.

College of Engineering, University of South Alabama

Pamela Moore, Ph.D.

College of Education and Professional Studies, University of South Alabama

Bethany Klemetsrud, Ph.D.

College of Engineering and Mines, University of North Dakota

1. Introduction

While artificial intelligence (AI) education in K-12 settings has grown rapidly in recent years, educators and researchers have expressed several concerns (Ali et al., 2019; Chiu et al., 2022; Marques et al., 2020; Ng et al., 2022; Yue et al., 2022). One primary concern was the complexity and abstract nature of AI concepts, as the core machine learning algorithms and theories extend beyond the standard secondary school curriculum. In addition, students found it challenging to grasp abstract concepts that were often disconnected from their everyday experiences. Another critical concern was the lack of trained teachers. The lack of teacher training often led to insufficient knowledge and confidence among teachers, as well as shortcomings in curriculum design and instructional guidance (Su et al., 2023).

To address these concerns, we developed a project titled “Integrating Culturally Relevant Project-based AI-integrated Learning” (CRPAIL, in brief). This project focuses on developing teachers’ knowledge of integrating AI in their Science, Technology, Engineering, and Mathematics (STEM) courses and embedding the integrated AI education in culturally relevant project-based learning. The purposes of this briefing paper are to 1) provide an overview of the teacher professional development program,

2) summarize our initial findings of its impact on the teachers' development and implementation of integrated AI lessons.

2. The CRPAIL Program

2.1 Structure of the CRPAIL Program

The CRPAIL program includes two components: summer teacher professional development (summer PD, in brief) and fall/spring classroom teaching. STEM teachers from the local and public high schools in Alabama and North Dakota participated in a variety of activities to learn AI technical foundations, AI real-world applications, and pedagogical strategies. The summer PD was designed based on Mishra and Koehler's (Mishra, 2019; Mishra & Koehler, 2006) technological pedagogical content knowledge (TPACK) framework and Kolb's (2014) experiential learning and has the following features:

The summer PD offered hands-on experiences to concentrate teachers' technological AI knowledge. Teachers followed the instructions and experimented with the Teachable Machine at the beginning of the summer PD to understand the key stages of supervised machine learning. Later, after the teachers understood basic AI concepts, the mentoring faculty and graduate research assistants guided the teachers to learn the Python programming on Raspberry Pi on image recognition. Towards the end of the summer PD, teachers joined the university labs and went on a field trip to John Deere to learn the AI applications in electrical engineering, cancer detection, diabetes detection, and agriculture (Figure 1). These activities aimed to concentrate AI learning with appropriate technology and tangible and visible outcomes.

Figure 1. Team Pictures



2023 Cohort experimenting circuit design



2023 Cohort working on image recognition on Raspberry Pi



2024 Cohort visiting two John Deere Plants in Fargo, ND

The summer PD also aimed to develop teachers' pedagogy knowledge of teaching AI and hence address the need to bridge the gap between AI learning and students' culturally relevant and real-life experiences. A two-day culturally relevant project-based learning (PjBL) was delivered during the summer PDs. Teachers discussed their students' cultural background and how it could be used in designing their curriculum. They were also immersed in real-life PjBL as learners in order to gain better insights of the pedagogy. For the 2023 cohort, teachers were guided to develop solutions for termite problems in southern Alabama. For the 2024 cohort, teachers were instructed to work on solutions for house insulation in the areas where teachers live, namely, Alabama and North Dakota.

To help teachers integrate AI into their STEM courses, the summer PD hosted multiple peer discussions and exchanges focusing on developing and teaching integrated AI lessons. Teachers who taught integrated AI lessons in the past year were invited to share their lessons and students' feedback with the new participating teachers.

2.2 Summary of the Summer PD Participation

Ten Alabama teachers participated in the four-week 2023 summer PD hosted at the University of South Alabama. Seven were female teachers, and three were male teachers. One teacher was African American, one was Asian, and eight were Caucasian. These teachers were from eight Title I schools, one suburban-rural school, and one public residential high school.

Five North Dakota teachers and six Alabama teachers participated in the 2024 summer program hosted at North Dakota State University. Eight teachers were female, and three were male. One was Asian, and ten were Caucasian. These teachers were from four metropolitan Title I schools, one suburban-rural school, one public residential high school, and five rural schools.

2.3 Summary of Fall/Spring Integrated AI Lessons

The 2023 cohort has completed their integrated AI lessons. Various support was offered after the 2023 summer PD, including a follow-up online workshop on a culturally responsive approach and one-on-one meetings between teachers and the research team. In addition, the research team and graduate research assistants visited teachers'

classes to help set up the devices, draft technology tutorials, and offer in-class lectures on AI knowledge and applications. Seven teachers reported that they taught integrated AI lessons in the fall of 2023 or spring of 2024. Four teachers implemented PjBL as a part of the integrated AI lessons. Research from only one representative AI-integrated class will be reported in Sections 3.2 and 4.2 due to the page limit.

3. Methodology

We have completed an initial mixed-method analysis, which provides insights and considerations for future studies. A convergent parallel design was deployed to collect and analyze the quantitative and qualitative data concurrently (Creswell & Clark, 2010). Results were then compared to obtain a comprehensive understanding of the research problems.

3.1 The Effect of the Summer PD

Our research question for the summer PD is “**How did the summer PD change teachers’ self-reported AI and AI teaching knowledge?**”. We adopted Mishra and Koehler’s (Mishra, 2019; Mishra & Koehler, 2006) TPACK instrument and replaced the content with AI to measure teachers’ perceived change of AI knowledge (AI knowledge, in brief) and their knowledge of using technology and pedagogy to teach appropriate AI knowledge (AI-TPACK, in brief). The modified instrument was utilized in the pre- and post-surveys. The online pre-survey was administered before the summer PD while the online post-survey was administered immediately after the summer PD. A paired sample *t*-test was conducted to examine changes in teachers’ AI knowledge and their AI-TPACK knowledge. We also conducted an independent sample *t*-test to examine the differences between two cohorts of teachers after their respective summer PDs.

Also included in both pre- and post-surveys were the culturally responsive teaching self-efficacy (CRTSE) (Siwatu, 2007). We adopted 13 questions relevant to what teachers learned in the summer PD, including teachers’ understanding of students’ culture and community backgrounds and the culturally relevant PjBL pedagogy. Please be aware that we were unable to obtain the 2023 cohort’s CRTSE responses before the summer PD, as it started before the award. As a result, we only collected the 2023 cohort’s CRTSE responses at the end of the summer PD. The Wilcoxon signed-rank test was conducted to detect changes in teachers’ CRTSE before and after the summer PD. We also conducted a Mann–Whitney U test to examine the differences between two cohorts of teachers after their summer PDs.

In the post-survey, we also collected teachers’ reflections on their learning experiences and impact through two open-ended questions. The first set of question focused on instructional methods and asked “1) *How did the instructional methods used in the summer PD affect your acquisition of knowledge?* 2) *How did these methods affect your lesson plan development?*” The second set of question probed the teachers’ perception of disseminating their summer PD experience to their peers and was “*Do you believe*

other teachers at your school could benefit from the information you have learned in this program? Do you have any plans to share what you have learned with fellow teachers?" We conducted thematic analyses to extract themes from the responses (Fereday & Muir-Cochrane, 2006).

3.2 Sample Integrated AI Lessons

In Fall 2023, one participating science teacher taught a cognitive science course to a class of teacher cadets. Students went to kindergartens and elementary schools and collected drawings from children of different ages. Students then participated in two project-based learning lessons that used the teachable machine (Carney et al., 2020), a supervised machine learning tool, to build a prediction system that determined the stage of artistic development (Lowenfeld, 1957) based on a child's drawing.

Our research question was **"how were semantic features of students' small group conversations related to their situational interests?"** We videotaped students' small group conversations in the two project-based learning lessons. The videos were transcribed for further semantic analysis. We used Linguistic Inquiry and Word Count (LIWC) software (version LIWC-22) (Boyd et al., 2022) to extract semantic features from the transcripts. At the end of each class, we collected students' situational interest in learning AI (Rotgans, 2015). A Spearman rank correlation was conducted to examine relationships between each LIWC feature and students' situational interests.

4. Key Findings

4.1 The Effect of the Summer PD

Key Takeaways:

1. The summer professional development that incorporated hands-on practices, peer discussions and exchanges, and project-based learning successfully improved teachers' self-reported AI knowledge and TPACK as well as culturally relevant teaching self-efficacy.
2. All participating teachers would like to share the resources and knowledge with their fellow teachers.

Results of the paired sample t-tests showed significant improvement in teachers' AI knowledge and their AI-TPACK after the summer PDs (Table 1). We did not find significant differences between the two cohorts of teachers' AI knowledge ($t(17) = .61, p = .55$) or AI-TPACK ($t(17) = .98, p = .34$).

Table 1. Teachers' AI Knowledge and AI-TPACK

		N	Mean	t	p
AI Knowledge	Pre-test	19	3.2105	-7.47	<.001

	Post-test	19	4.2895		
AI-TPACK	Pre-test	19	2.8860		
				-7.77	<.001
	Post-test	19	4.2807		

A significant improvement was identified on 2024 cohort's CRSTE (Table 2). We did not find significant differences between 2023 and 2024 cohorts' CRSTE after their summer PDs, $U = 36$, $p = .82$.

Table 2. 2024 Cohort CRSTE

		N	Mean	Z	p
<i>CRSTE</i>	Pre-survey	8	4.04	-2.20	.03
	Post-survey	8	4.58		

Qualitative thematic analysis of teachers' written responses also suggested that the summer PD in both summers were successful. Teachers' reflections on the impact of the summer PD instructional methods were very positive. Almost every response praised the culturally relevant PjBL workshop, e.g. *"Group discussion was a highly effective way of acquiring knowledge, as was the PjBL strategy workshop. ... The PjBL workshop led to the creation of a project-based learning activity that I plan to use this year."* In both cohorts, teachers actively participated in group discussions and solution planning, which enhanced their awareness and use of students' cultural backgrounds in their AI lessons, as evidenced by the quantitative CRSTE results. Other methods such as hands-on practice, peer sharing and discussion, and online module design were also appreciated by the teachers.

All of the teachers confirmed that they would share their knowledge and resources with their colleagues in their school districts. What they planned to share included resources as well as specific topics and workshops acquired in the past summer PDs, e.g. *"I plan on sharing the resources at our professional development days at the beginning of the school year."* As most of the participating teachers were from Title I, suburban, or rural schools, their knowledge sharing with their colleagues will undoubtedly broaden the AI education to other students from historically marginalized groups.

4.2 Results from the Sample Integrated AI Lessons

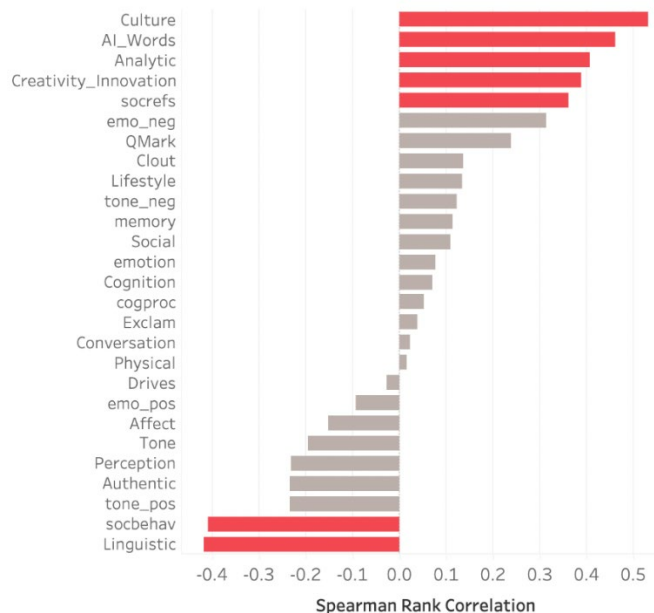
Key Takeaways:

1. Students' engagement in discussions about using AI and its underlying mechanisms was positively associated with their high level of interest in AI learning.
2. Students' low level of interest manifested in their off-topic conversations and their minimal effort to clarify AI topics.

Results showed that students' use of words related to technology (shown as *Culture* in Figure 2), AI (Mishra et al., 2022), logical and formal thinking (shown as *Analytic* in Figure 2), and creativity & innovation (Ahmed & Feist, 2021; Neufeld & Gaucher, 2017) were significantly and positively correlated with students' situational interests (Figure 2). For examples, conversation like *"We are comparing like what we would need to tell our machine."* suggested the student's use of technology terms. When a student discussion was like *"Okay, there's a setting on the teachable machine it is basically how many times the machine literally looks at every single picture."*, it suggested that the student was involved in logical thinking of how teachable machine recognized pictures. Their positive and significant association with situational interest suggests that students' engagement in discussions about using AI and its underlying mechanisms led to an increase in their interest.

Additionally, features related to communication (shown as *socbehav* in Figure 2) and linguistic dimensions were found to have notable negative correlations with interest. When a student used communication words, like *"say"*, *"tell,"* it usually indicated that he/she relayed other's words without making efforts to explain it, e.g. *"Visual and then what the computer says, and that's it"*. When a conversation carried a lot of function words, like this example *"They're actually, well, the drawings are in the car, sadly. But there are some that are like, you know, really good."*, it suggested that the conversation focus could be off-topic or shifted away from the main topic to a related but tangential point.

Figure 2. Results of Spearman Rank Correlations



5. References

- Ahmed, S. T., & Feist, G. J. (2021). The Language of Creativity: Validating Linguistic Analysis to Assess Creative Scientists and Artists. *Front Psychol*, 12, 724083. <https://doi.org/10.3389/fpsyg.2021.724083>
- Ali, S., Williams, R., Payne, B., Park, H., & Breazeal, C. (2019). Constructionism, Ethics, and Creativity: Developing Primary and Middle School Artificial Intelligence Education. International Workshop on Education in Artificial Intelligence K-12 (EDUAI '19), Palo Alto, CA.
- Boyd, R. L., Ashokkumar, A., Seraj, S., & Pennebaker, J. W. (2022). *The development and psychometric properties of LIWC-22*. <https://www.liwc.app>
- Carney, M., Webster, B., Alvarado, I., Phillips, K., Howell, N., Griffith, J., . . . Chen, A. (2020). *Teachable machine: Approachable web-based tool for exploring machine learning classification* Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems, Honolulu, HI. <https://doi.org/10.1145/3334480.3382839>
- Chiu, T. K. F., Meng, H., Chai, C.-S., King, I., Wong, S., & Yam, Y. (2022). Creation and evaluation of a pretertiary artificial intelligence (AI) curriculum. *IEEE Transactions on Education*, 65(1), 30-39. <https://doi.org/10.1109/TE.2021.3085878>
- Creswell, J. W., & Clark, V. L. P. (2010). *Designing and conducting mixed methods research* (2nd. ed.). SAGE Publications.
- Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International journal of qualitative methods*, 5(1), 80-92.
- Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development* (2nd. ed.). Pearson.
- Lowenfeld, V. (1957). *Creative and mental growth*, 3rd ed. Macmillan.
- Marques, L. S., Gresse Von Wangenheim, C., & Hauck, J. C. R. (2020). Teaching machine learning in school: A systematic mapping of the state of the art. *Informatics in Education*, 283-321. <https://doi.org/10.15388/infedu.2020.14>
- Mishra, P. (2019). Considering Contextual Knowledge: The TPACK Diagram Gets an Upgrade. *Journal of Digital Learning in Teacher Education*, 35(2), 76-78. <https://doi.org/10.1080/21532974.2019.1588611>
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teacher knowledge. *Teachers College Record*, 108(6), 1017-1054. <https://doi.org/10.1111/j.14679620.2006.00684.x>
- Mishra, S., Ewing, M. T., & Cooper, H. B. (2022). Artificial intelligence focus and firm performance. *Journal of the Academy of Marketing Science*, 50(6), 1176-1197. <https://doi.org/10.1007/s11747-022-00876-5>
- Neufeld, K. H. S., & Gaucher, D. (2017). *Creativity and innovation dictionary: Dictionary for use with Linguistic Inquiry and Word Count software*.
- Ng, D. T. K., Lee, M., Tan, R. J. Y., Hu, X., Downie, J. S., & Chu, S. K. W. (2022). A review of AI teaching and learning from 2000 to 2020. *Education and Information Technologies*. <https://doi.org/10.1007/s10639-022-11491-w>
- Rotgans, J. I. (2015). Validation Study of a General Subject-matter Interest Measure: The Individual Interest Questionnaire (IIQ). *Health Professions Education*, 1(1), 67-75. <https://doi.org/10.1016/j.hpe.2015.11.009>
- Siwatu, K. O. (2007). Preservice teachers' culturally responsive teaching self-efficacy and outcome expectancy beliefs. *Teaching and Teacher Education*, 23(7), 1086-1101. <https://doi.org/10.1016/j.tate.2006.07.011>

- Su, J., Ng, D. T. K., & Chu, S. K. W. (2023). Artificial Intelligence (AI) Literacy in Early Childhood Education: The Challenges and Opportunities. *Computers and Education: Artificial Intelligence*, 4. <https://doi.org/10.1016/j.caeai.2023.100124>
- Yue, M., Jong, M. S.-Y., & Dai, Y. (2022). Pedagogical design of K-12 artificial intelligence education: A systematic review. *Sustainability*, 14(23). <https://doi.org/10.3390/su142315620>