Charting the Course: Decoding K-12 AI Education at a Youth-Led Multimodal Workshop

Shuhan Li[1], Rishikesh Sankaran[2], Roozbeh Aliabadi[1]

[1] ReadyAI, Pittsburgh, PA 15206
[2] FutureLeadAI, Raleigh, NC 27513

ABSTRACT
Early acquisition of Artificial Intelligence (AI) fluency is increasingly imperative. While K-12 AI education has flourished in the past years, most initiatives require a certain degree of coding background. This mixed-method study examines a project-based and largely unplugged AI education initiative entitled "Charting the Course," led by a high school sophomore based in North Carolina. 18 students of Grade 5-9 attended the workshop. Pre- and post-surveys assess students' changes in knowledge levels and cognitive development. Qualitative instruments such as participant observation, interviews, and open-ended questions provide additional insights into key design elements associated with the changes. Quantitative results demonstrate significantly deepened knowledge levels, positive attitude shifts, strengthened tendency to learn, and enhanced job inclination in AI. Design components such as gamification, project-based learning, multimodality, and embedded ethics contribute to students' maximized agency and therefore meaningful outcomes. Middle school students are able to grapple with the merits and risks of AI. The lesson plan inspires students to harness the use of AI for societal and environmental betterment. Youth mentorship also stimulates students' continued interest in AI. Findings from this research could inform scholars and practitioners in facilitating, implementing, and assessing AI education initiatives led by youth and for youth.

KEYWORDS
K-12 AI Education, Youth-Led Initiatives, Project-Based Learning, Ethics-by-Design.

1 Introduction

Artificial intelligence (AI) is rapidly reshaping industry and redefining education. As AI permeates every fabric of society, young learners should be prepared for a digitized era. The transient nature of AI requires the school system to adapt to the digital transformation. Early acquisition of AI knowledge among young learners will soon become the top priority (K12CS, 2016). Given the rising demand for K-12 AI education, this study assesses a local educational initiative disseminating AI literacy for young learners. We document the experience and evaluate the outcomes of 18 students of Grade 5-9 who participated in a youth-led project-based AI workshop entitled "Charting the Course." This mixed-method study examines the immediate impact of the workshop on students' AI knowledge acquisition and attitude shift in continuous learning. Quantitative instruments through pre- and post-surveys gauge the measurable outcomes, while qualitative information from student interviews and participant observation yields in-depth narratives about the program experience. This study offers a point of reference for inclusive AI education, informing future curriculum development and youth initiatives in the field. This study aims to broaden the participation of AI programs among middle school students with little to no coding backgrounds; to explore the role of youth-led initiatives in early acquisition of digital skills and AI ethics; to provide empirical evidence for K-12 AI education with curricular resources, classroom practices, and organizational frameworks; and to inform educators and decision-makers about innovative and inter-active course design that caters best to young learners of AI. Two research questions (RQs) guide our inquiries:

RQ1: Does "Charting the Course" affect students' knowledge level, interest, attitudes, tendency to learn, and job inclination regarding AI?

RQ2: What design components in "Charting the Course" are applied to affect students' learning outcomes and attitudes?

2 Literature Review

2.1 Current State of K-12 AI Education

K-12 AI education has rapidly developed over the past years (Casal-Otero et al., 2023; Su et al., 2023). Existing literature focuses the learning experience of AI literacy and the implementation of AI tools in K-12 settings (Casal-Otero et al., 2023). The first branch primarily inquires basic content knowledge, such as recognizing common AI applications and mechanisms. The second branch probes into design elements, including curriculum, pedagogies, and ethics (Casal-Otero et al., 2023). Resources such as demos, activities, tools, and curricula have emerged (Druga et al., 2022; Grover, 2024). These multimodal resources have all opened up pathways for educators of varying levels to start incorporating AI content in their subject areas (Druga et al., 2022). Structured and scalable frameworks of curriculum and instructional design are available, catering specifically to the young audience (Touretzky et al., 2023; Grover, 2024) and widely adopted by practitioners (Druga et al., 2022).

Challenges remain in the consistency and clarity in instructional guidance (Druga et al., 2022), teacher capacity, and assessments (Su et al., 2023; Grover, 2024). Sparse empirical evidence exists for the effectiveness of AI education for young students; further, current inquiries primarily revolve around coding- and robotics-driven lessons (Su et al., 2023). K-12 AI education is largely confined to computer science, potentially limiting its accessibility to non-STEM learners

(Druga et al., 2022). Researchers also suggest the increasing need for teacher readiness in technical fluency and demystification of AI (Grover, 2024). Pedagogy-wise, teachers may deploy age-appropriate teaching materials using project- and play-based learning methods (Su et al., 2023). Finally, a greater emphasis on AI's societal impact is necessary yet existing course materials hardly address (Druga et al., 2022).

2.2 The Digital Divide

Digital divide describes the unequal access to digital technologies that could result in disproportionate levels of digital fluency (Warschauer et al., 2004; Hernandez, 2023). Socioeconomic status (SES) and geographic location are two definitive factors. Low-SES households lack means to acquire digital devices, nor could they leverage adequate connectivity to obtain information about technological knowledge (Hernandez, 2023). When digital exposure is increasingly linked to AI literacy (Celik, 2023), bridging the digital gaps becomes ever more necessary. Otherwise, the digital divide could ultimately lead to limited academic opportunities and career pathways for underserved students (Hernandez, 2023). Closing the digital divide requires far more than expanding accessibility. Students from higher SES engaged in more sophisticated applications such as statistical analysis, whereas their lower SES counterparts primarily used it for basic internet searches. Of greater importance is leveling the playing field of advanced technological deployment. This calls for inclusive pedagogy and home support, as well as deepening technological use in education (Warschauer et al., 2004). Unplugged activities tackle the disparity by developing computational thinking without the overreliance on digital infrastructure through "playful challenges, facilitated discussions, group problem-solving, accessibility to fundamental and generative concepts, and a high regard for participants' ability to conduct inquiry" (Huang & Looi, 2021, p.6). The unique non-digital representation of knowledge to some extent removes the technical barriers and provides foundational cognitive skills before formally introducing learners to coding (Huang & Looi, 2021).

2.3 Youth Experience with AI Education

Youth engagement in technologies and AI has been of growing interest and importance. Young learners have become more than just passive users of digital technologies, but are active agents of innovative thinking (Bokil, 2024). Youth have started to deploy emerging technologies for problem-solving and community betterment (Bokil, 2024). Guided learning experience through digital literacy acts as a crucial means to help young learners better navigate technologies through adequate training and support network (Bokil, 2024). AI education initiatives shall gradually adopt a youth-driven approach (Irgens et al., 2022). Case studies from evidenced the necessity of youth-centered courses through participatory frameworks (Irgens et al., 2022; Hamburg et al., 2024). Students had better experience tinkering with digital tools when they could deliver their own technological implementation plans, under teachers' constructive guidance (Irgens et al., 2022). When students claimed their agency as co-creators of digital knowledge and applications, their learning experience became more meaningful and thus their understanding more enduring (Humburg et al., 2024).

Generally, young students can articulate basic knowledge about AI (Humburg et al., 2024; Greenwald et al., 2021). Nevertheless, AI may still present to most young students as a "black box"; even for those with some coding background, the mechanisms of AI may be difficult to internalize at the beginning (Greenwald et al., 2021). Representation of knowledge also matters. Young learners prefer concrete examples and immersive learning with real-world or personal relevance (Irgens et al., 2022; Humburg et al., 2024), as opposed to abstract concepts (Greenwald et al., 2021). Above all, youth are keen observers of AI's complex societal impacts, and are able to discuss AI ethics (Irgens et al., 2022; Hamburg et al., 2024). Teaching AI to young students starts with the demystification of the technology, along with cultivating a supportive environment for practical training and empathetic conversations.

This study ties itself to the growing body of work and practices in K-12 AI education. The current study addresses two major gaps in existing literature. Firstly, case studies about youth's encounters with AI rarely involve youth-led programs, as most courses were designed and conducted by adult faculties. Second, ethics-by-design resources are generally lacking. Therefore, this study may add insights to the K-12 AI education discourse by examining a youth-led project-based workshop.

3 Program Synopsis

"Charting the Course" is designed and implemented by a high school student based in North Carolina. Through community partnerships, this weekend workshop was held at the shared workspace of a local non-profit organization. The program aims to bring young students together to explore the AI technologies. Offering an interactive and project-based experience, "Charting the Course" incorporates hands-on activities that deepen students' knowledge about AI, as well as their willingness for continued learning. The course content revolves around the Five Big Ideas of AI (Touretzky et al., 2023). Each activity addresses at least one big idea, with a particular focus on societal impact.

"Charting the Course" embodies three leading paradigms: project-based learning (PBL), playful learning, and universal design for learning (UDL). PBL highlights students' creativity in a collaborative environment (Boston University, n.d.), where the instructor deliberately engages learners in groupwork settings and left adequate room for self-driven inquiries. Besides, the program integrates playful learning to enhance young learners' attentiveness (Samuelsson, 2024; Hughes, 2013). This caters to young learners' behavioral features, such as entertainment and games. Last but not least, UDL principles inform the program's multimodal instruction for greater accessibility for students of all knowledge levels. At the core of its design, "Charting the Course" engages learners in various ways, combining small lectures, demos, and hands-on activities. High interactivity allows students to formulate strong communication skills (CAST, 2024; Ecker, 2023).

To begin, students watched a short video about AI definitions for young learners. The first warm-up activity, “AI or Not,” asked students to identify key characteristics of AI using the guiding questions from MIT RAISE (n.d.). The instructor presented a series of artifacts on the slideshow. Students discussed whether the artifact was considered an AI. The cohort then moved to the lab for the Campfire S’mores Chef activity. The activity began with explaining the big ideas of Representation and Reasoning and Machine Learning. In an imagined camping scenario, students joined a “cookout” to customize their s’mores. This activity simulated the reasoning and supervised learning mechanisms where AI follows specific instructions to complete a task. Each group worked with a set of paper-cutout “ingredients.” The cutouts contained items that belonged in a s’more (e.g. crackers, chocolate, and marshmallows) and items that did not (e.g. vegetables, pizza, and eggs). One member of each group role-played as an AI agent to assemble the s’mores. The groups then trained their “AI” per-son with various combinations to identify the features of a s’more. The groups proceeded to retrain their AI through feedback loops, documenting the success and challenges during the process.

The whole class relocated to a conference room for Campsite Cruiser. The center space was open for simulations, and the surrounding space for workstations. Through a panoramic Waymo self-driving car experience, students learned the essential functions of an autonomous vehicle. On written worksheets “ML Journal,” students reinforced the technique of machine learning. In a simulative setting, students logged onto an online meeting with a fictional character named “Sasha,” the director of Camp Woodstock. Sasha debriefed and assigned tasks of designing a self-driving car that could transport campers around the forest. After 5 minutes of ideation, the groups delineated how their cars would respond to environmental changes and obstacles using sensors and reasoning. Students then ran their flowcharts on a foldable-fabric map sheet. They placed different obstacles like animals, trees, and rocks along the way to represent changing road conditions. Finally, students assessed their flowcharts and presented outcomes to the class.

The workshop culminated at the LA Wildfire project. Students first watched a brief video about the Los Angeles wildfires that contextualized the problem statement. The project would address 2 of the 3 main aspects: Prevent, Protect, and Persist. Students worked together at their designated workstations with laptops, design materials, and a TV screen. Each group built their models around Natural Interaction and Societal Impact. Students conducted brief research on 3 existing AI technologies for wildfire interventions, and then polished their ideas at the ideation station using sticky notes. Students prototyped on a virtual design board, detailing their designs through graphics and drawings. Students presented their blueprints, pitched their demos, and evaluated the foreseeable benefits and perceived risks of their AI models. In a gallery-walk format, students circulated among stations to interact with and provide feedback on each other’s projects.

4 Methodology

This study adopts a mixed-methods approach for a comprehensive understanding of the design, experience, outcomes, and impact of the program. Quantitative instruments consist of pre- and post-surveys using a Likert scale from 1-5, with 1 being "Strongly Disagree" and 5 being "Strongly Agree," measuring students' interest, attitudes, tendency to learn, and career goal-setting. A questionnaire of 7 questions (6 multiple choice questions and one true/false question) assesses students' knowledge level in AI concepts. Repeated measures ANOVA measures the change in these constructs. Quantitative measures aim to answer RQ1.

Qualitative instruments include student interviews before, during, and after the program; students' write-in responses to the open-ended questions before and after the program; participant observation of classroom setups and interpersonal dynamics during each activity; and instructor feedback from on-premise faculties. Qualitative instruments add insights and explanations to quantitative findings, responding to RQ2.

18 students participated in the program in 2 cohorts (10 in the first cohort, 8 in the second cohort). Table 1 indicates the number and percentage of student participants based on grade levels. Students attended voluntarily. The program organizer distributed the online registration portal to local schools and emailed relevant faculty members to recruit prospective participants.

Table 1. Distribution of Students' Grade Levels

Grade Level	Frequency (n)	Percentage (%)
5	5	27.7
6	3	16.7
7	6	33.3
8	3	16.7
9	1	5.6
Total	**18**	**100.0**

5 Findings

5.1 Quantitative Measures

16 of the 18 students responded to the pre- and post-surveys (response rate of 88.9%). Table 2 displays the descriptive statistics of the mean and standard deviation for each of the 5 constructs.

Table 2. Descriptive Statistics for Pre- and Post-Measures

Measure	Mean	Standard Deviation	n
Interest (pre)	8.94	1.063	16
Interest (post)	9.44	0.964	16
Attitude (pre)	12.88	2.209	16
Attitude (post)	13.94	1.436	16
Tendency (pre)	8.38	1.204	16
Tendency (post)	9.38	0.885	16
Job Inclination (pre)	11.94	2.380	16
Job Inclination (post)	13.38	2.062	16
AI Knowledge (pre)	4.00	1.826	16
AI Knowledge (post)	5.37	1.500	16

Most students (47.1%) had not participated in AI-related courses prior to the workshop. A smaller percentage of them (35.3%) had limited experience with AI training, having taken one lesson outside of the program. Students with continuous AI learning experience made up less than 18% of the cohorts. The composition of past experience implies the limited background knowledge of AI among most students.

The repeated measures ANOVA results are presented in Table 3.

Table 3. Pairwise Comparisons of Measures Over Time

Measure	(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference
						Lower Bound
Interest	1	2	-0.500	0.242	.056	-1.015
	2	1	0.500	0.242	.056	-0.015
Attitude	1	2	-1.063*	0.433	.027	-1.985
	2	1	1.063*	0.433	.027	0.140
Tendency	1	2	-1.000*	0.274	.002	-1.584
	2	1	1.000*	0.274	.002	0.416
Job Inclination	1	2	-1.438*	0.540	.018	-2.588
	2	1	1.438*	0.540	.018	0.287
AI Knowledge	1	2	-1.375*	0.473	.011	-2.384
	2	1	1.375*	0.473	.011	0.366

Note. * *The mean difference is significant at the* $p < .05$ *level.*

The ANOVA results show that the 16 respondents have seen statistically significant increases ($p < .05$) in all measures except for interest level. Students have become more motivated to pursue AI knowledge after the course. They have started realizing AI's presence in jobs and everyday life, and planned to use AI on a regular basis for positive intents. The increase in interest level is non-significant.

5.2 Qualitative Measures

5.2.1 AI through Youth Narratives

Before the workshop, students' perceptions on AI varied. Most of them were able to enumerate commonly used AI applications, such as ChatGPT. Many acknowledged AI's capabilities in problem-solving. They described AI as a helper to humans, such as offloading grunt work. A few students also addressed AI as "the future." One student drew on their personal experiences with AI agents to illustrate how AI could benefit them personally, as in customer service chatbots. They frequently used words like "help," "assist," "easier" and "convenient" to indicate AI's merits. On the other hand, some students recognized the potential harm. They were concerned about AI-generated "lies," indicating awareness of misinformation. Nevertheless, most students' understanding remained surface-level.

Students' perspectives evolved during and after the program. They began to recognize AI's capabilities beyond mere automation, identifying its learning and decision-making abilities. They also incorporated the Five Big Ideas into their definitions. Other students shared their understanding of feedback loops where AI could improve through trials and errors using additional data. Expressions like "learn and adapt," "improve," and "get better over time" implicate students' dynamic views on machine learning techniques, understanding AI as an adaptive entity rather than a static tool. A more critical view also emerged on AI's role in society. More students recognized AI's possibility of job displacement and its influences on human decision-making. These statements illustrate an increased awareness of AI's dual nature: its ability to enhance efficiency while simultaneously imposing challenges on industries. Some students expressed that they would like to explore AI's negative impacts and ways to improve accuracy. Although ethical considerations remained simple, these early concerns underscored students' growing societal awareness.

Students exhibited willingness to apply AI to solving real-world problems. One student (VT, G8) shared that they wanted to learn more about Representation & Reasoning, because "it is interesting how [AI models] can reason and solve problems." Other students provided a few more concrete examples such as "[solving] the problem of wasting paper" (JR, G7) and "[getting] rid of human's social anxiety" (TP, G9). In these responses, students showed empathy for socioemotional and environmental well-being. This suggests a step forward from the pre-program narrative about self-benefiting use of AI, to a more altruistic application.

5.2.2 Multimodal Learning Experiences

Students found the hands-on activities both enjoyable and educational, shown in their frequent use of "fun," "creative," and "interesting" to describe their overall experience. These emotional cues accentuated the affective appeal of gamified learning processes. In particular, the organization of these activities played a decisive role in shaping the positive feedback. Students appreciated collaboration, peer interactions, and flexibility to brainstorm their own ideas.

The lenient problem space built student agency as well. One student (SK, G7) mentioned the benefits of self-paced projects, offering a balance between independent and collaborative work. This not only gave students ample freedom to develop their respective work plans, but also brought them together with their peers to foster friendship and a sense of belonging. Interpersonal contacts and augmented agency allowed students to comfortably navigate the workshop.

Several students complimented the final presentation. They thought that making their own app to "help out other people" (TP, G5) was fulfilling, and that the practicality of this project elevated the engagement. Presentations gave voice to young students. They showcased their ideas with their peers, deepening mutual support and fostering a sense of achievement. The practical nature of their final deliverables validated their creativity by connecting their designs to real-world significance.

5.2.3 Personal & Societal Factors

Prior to the workshop, students were asked about their favorite subject(s) at school, as well as their motivation for participation. Many students expressed interest in STEM-related subjects. 4 of the 18 students talked about their fondness of Science subjects; one student specified Physics and another Mathematics. 3 students mentioned coding as an integral part of AI, indicating familiarity with the connection between programming and AI. 2 students wanted to learn coding, one of whom already equipped with basic coding knowledge. These responses could imply that pre-existing conceptualization of computing and AI might motivate young students to pursue learning opportunities like "Charting the Course."

External factors from families and peers could also shape the learning experience. When asked about the reason for attendance, 5 students mentioned that their parents (mother) signed up for them. One student whose mother was a software engineer was also driven by her friend's recommendation. Another student had attended a similar class elsewhere with her cousins. Family support could serve as an intangible factor shaping students' tendency to learn. Further, one student showed specific appreciation to the instructor by complimenting his personable teaching style. Youth leadership could establish an approachable environment, assuring students of a supportive workshop experience.

6 Discussion

We observed statistically significant improvements in students' AI knowledge level, attitudes towards AI, tendency to learn, and job inclination. This finding supports the immediate effectiveness of "Charting the Course." Similar studies yielded positive outcomes in students' mastery of AI and machine learning (Dai, 2024; Zhang et al., 2022). Practical hands-on activities could also contribute to students' career interest (Zhang et al., 2022). Positive attitude shifts are commensurate with previous programs using interactive and participatory methods (Mavromihales et al., 2019; Trifonova et al., 2024; DiPaola et al., 2020). Although the increase in interest level was non-significant, one possible explanation would be the ceiling effect (Staus et al., 2021). The baseline interest could be high, limiting the room for further measurable growth. Students' interest level might also be stable over time, influenced by existing preferences (Bognár & Khine, 2025).

Qualitative findings consolidate the pedagogical soundness of PBL, playful learning, and UDL. Multimodality is proven to be effective from the study by Abu-Boateng & Goodnough (2022), where students had the freedom to choose their preferred formats of assessments and deliverables. Collaborative hands-on activities centered students' agency and interest, thus stimulating their cognitive development via learning by doing (Trifonova et al., 2024). Gamification also enhanced students' learning experience and augmented knowledge internalization (Mavromihales et al., 2019). Student-centered and humanistic design laid out the theoretical foundations for learners' success (Trifonova et al., 2024; Mehrotra & Sinha, 2024).

Contexts and formats also matter. This community-driven program provided learning opportunities for students with limited previous exposure to AI. A non-formal learning environment helps young learners learn about AI in culturally responsive and resourceful ways (Mehrotra & Sinha, 2024). Extracurricular activities expand "the inclusive ecosystem at an early stage when attitudes and aspirations are being shaped" (Mehrotra & Sinha, 2024, p.506). Unplugged projects translated AI knowledge into accessible and age-appropriate formats without the prerequisites of programming (Bell et al., 2009; DiPaola et al., 2020). Role plays and gamified group projects are also proven strategies to teach AI (Lim et al., 2024). Whereas some unplugged classrooms relied solely on discussions (DiPaola et al., 2020), "Charting the Course" synthesized discussions and prototyping beyond abstract concepts, thus broadening the participation of AI education (Bell et al., 2009).

Thanks to ethics-by-design lesson plan, "Charting the Course" threads societal impacts and ethical principles through-out each activity (Williams et al., 2023). The Wildfires activity not only guided students to apply AI to tangible scenarios, but also developed their environmental stewardship and compassion. Embedded ethics could inspire students to develop AI systems in meaningful ways, critically examining AI's complex influences on society (Williams et al., 2023). Students could better articulate their concerns and enumerate potential stakeholders for accountability (Ali et al., 2021). Although young students may have yet to engage in highly sophisticated conversations (Morales-Navarro et al., 2023; Dai et al., 2024), they nevertheless grappled with AI's promises and problematics (Zhang et al., 2022). Students' willingness to address the ethical issues post-program also proves that, to young learners, the challenges of AI are imminent but not insurmountable (Morales-Navarro et al., 2023). "Charting the Course" has prepared youth for continuous inquiries in AI with greater nuance.

Learner agency is another salient feature. The course encouraged students to utilize creativity and showcase the end results. This amplifies and validates students' own narratives (Williams et al., 2023). Students were able to think creatively in open and creative processes (Martin et al., 2024). In the Campsite Cruisers activity, the instructor devised a highly customizable roadmap and figurines to simulate various road conditions. The flexible design space provides students with ample room to tinker with their designs in role-based group work (Martin et al., 2024). The instructor's careful guidance mitigated the problem of the over-reliance on AI (Lee et al., 2024); the overly optimistic sentiment started to compromise, as students adopted a more cautious view on AI. "Charting the Course" meticulously manages the freedom to explore AI while offering necessary support for critical thinking.

Finally, youth leadership distinguishes the program from past contributions. Peer mentorship could create a role model effect on young learners (van Dijk & Noorda, 2019; Atif et al., 2022). Youth between Grade 5-9 are exploring their identity and academic interest, where peer support facilitates this process (Atif et al., 2022). Empathy among youth would strengthen their efficacy and sense of responsibility (van Dijk & Noorda, 2019), implicated through students' seamless cooperation and mutual support during the activities. Amplifying youth's voice is imperative given their frequent exposure to the technology (Bouziane, 2025). In a co-created interactive space, both the youth instructor and students forge computational thinking, design responsible AI, and narrate their unique stories.

7 CONCLUSION

This mixed-method study of the youth-led multimodal AI workshop "Charting the Course" demonstrates the program's preliminary success in enhancing students' computational thinking and AI fluency. Quantitative findings show significant increases in knowledge acquisition and socioemotional development among participants. Although interest levels did not rise significantly, this could be attributed to the already high baseline value. Nevertheless, the strong enthusiasm underscores the intrinsic motivation among youth to engage with AI. Qualitative insights elaborate on the agency-maximizing elements in PBL, gamification, and unplugged activities that enhance accessibility and deepen ethical awareness. In summary, "Charting the Course" positions young learners as active agents and critical thinkers exploring AI's complexity.

This study contributes scholarly and practically. Findings provide empirical evidence in the underexplored field of youth-driven AI education that supports peer-led knowledge-sharing and culturally responsive pedagogy in K-12 settings. For researchers, the findings invite further investigation into youth mentorship's role in shaping AI knowledge. Practitioners can draw from the program's successful strategies like multimodal knowledge representations and co-teaching with youth to design age-appropriate, interactive, and ethics-driven curricula. Future endeavors can benefit from a larger and more diverse student body, assessed through longitudinal measures. Ultimately, "Charting the Course" exemplifies the prospect in centering youth's leadership and perspectives in AI education. Equipped with digital fluency and ethical consciousness, the Course Charters of today will emerge as the Changemakers of tomorrow.

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