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An Analysis of Teacher Practices and Student Participation in Contrasting Activity Systems in an AI Educational Program

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Abstract: In this paper, we investigated the activity systems in two contrasting upper-elementary classrooms and drew on analyses of discourse between teachers, researchers, and students during an AI curriculum intervention. We examined the role teachers' practices played in setting the stage for classroom discussions and interaction. Despite the teachers appropriating different components of the same curriculum depending on their teaching strategies and classroom cultures, to attain the learning objectives, pre- and post-assessment results revealed that both teaching approaches led to similar student learning outcomes indicating that there are multiple ways to teach a pre-designed curriculum.

Introduction

AI education has begun to gain prominence in K-12 education (DeLyser & Born, 2021). However, there is little work exploring how classroom interactions influence students' understanding of AI concepts. Our project explores approaches to AI education along with the development of PrimaryAI, a curriculum for upper elementary-aged students (Glazewski et al., 2022). The curriculum has multiple resources, activities, and discussion prompts to foster classroom interactions. Differences in how teachers use these tools and resources can lead to varying forms of classroom engagement (Hmelo-Silver et al., 2015), which raises the question of the impact that these different enactments may have on student learning depending on how the curriculum resources are used to mediate learning. We provide a comparative case study between two classrooms where the teachers taught the same unit of the AI curriculum regarding teaching practices, mediators and tools, and learning outcomes. We observed how depending on teacher practices and classroom cultures, the same lesson from a unit in the curriculum was delivered in a different manner and yet yielded similar student learning outcomes.

Method

Our team collaborated with two teachers in the Midwest to design an AI curriculum to introduce AI learning experiences into their upper-elementary classrooms, 35 4th graders and 27 5th graders. The pre-and post-tests were administered at the beginning and end of each unit respectively. Implementation of Unit 1(computer vision), Unit 2(machine learning), and Unit 3(AI planning) were completed in both classrooms over three weeks.
This study investigates two primary questions:

1. What is the impact of different teacher practices on discourse and students' understanding of AI concepts?
2. What are teachers' perceptions of the AI curriculum, and what is the relationship between these perceptions and teacher practice?

Theoretical framework: Activity theory

Activity theory (AT) was used to understand the role of the teacher's instructional strategies aligning with the idea that learning always occurs in social and cultural contexts (Levinson et al., 2000). Our focus was to understand how the teachers use different resources as mediators to facilitate learning. Viewing the two classrooms as complex activity systems, our goal was to compare these two systems to explore how learning was mediated in these two contexts and to understand its impact on student learning outcomes. Activity theory offers a conceptual framework for studying human behavior and provides a framework for conceptualizing different social interactions, materials, resources, and norms that enable and constrain what individuals and a collective group can accomplish (Leont'ev, 1978). The six core components of an activity system include subject, object, mediating

artifacts or tools, rules, community, and division of labor (Engestrom, 1987). In this study, we compared the two activity systems that represented the different entities and interactions in the two classrooms.

Data sources and analysis

To understand the student interaction, discourse, and teacher role in the two classrooms, we examined a total of 8 hours of video data from both classrooms. Field notes were also used for analyzing classroom interactions and teachers' pedagogical practices. To evaluate student learning gains in both classes in this study, we calculated descriptive and within-group inferential statistics. We applied mixed methods to analyze the pre-and post-test data quantitatively and analyze representative clips from the video data qualitatively. For the video data, we conducted a moment-by-moment analysis to investigate the discourse during the learning process, mainly focusing on teacher-student and teacher-researcher-student interactions. To further understand the teachers' mediating and discourse practices, we attempted to gather their perspectives through semi-structured interviews. We qualitatively analyzed the data inspired by thematic analysis to find evidence relevant to understand the teachers' strengths and how they leveraged them to mediate classroom interactions and appropriate the curriculum.

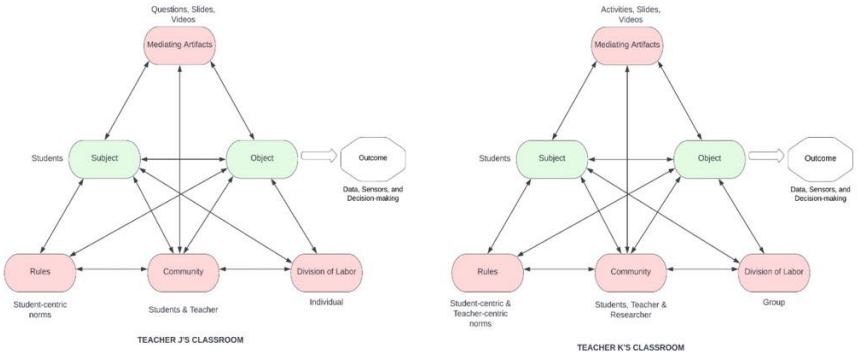
Results

Activity system comparison

We analyzed the classroom videos and our field notes from two classrooms and observed that they varied in context, classroom culture, and the role of the teacher, leading to different student interactions and discourse. Both teachers taught the same lesson: data, sensors, and decision-making from Unit. However, they differed greatly with respect to the way they introduced the concepts and engaged with the curriculum resources and materials. This had a subsequent impact on classroom dynamics including the different teacher-student and student-student interactions. We compare the two activity systems representing the classrooms for similarities and differences as shown in Figure 1. We summarize the classroom interactions between teachers and students in these two activity systems, by each component, where the teachers taught a lesson from Unit 1(Computer Vision), which was designed with the objective that the students will leave with the idea that "humans use data to see or create an informed decision, and computers also behave similarly when it comes to gathering data through different sensors to make decisions."

Figure 1

Activity System Comparison



Mediating artifacts

The key mediator that Teacher J used to her strength was the leading questions from the curriculum that she posed to encourage student interactions and discourse. A moment-by-moment analysis showed how students interacted with the teacher and engaged with the content through conversations. The first question she posed was: "*How does a computer learn?*" A few open-ended student responses that were based on their prior knowledge included "*maybe a human teaches it," "some program," "maybe it is programmed to do that," "it has a thing inside it that allows it to change the program and learn new things."* These responses revealed that although the students did not have a clear understanding of how computers learn, they knew that there was some training involved –*" a human teaches," "some program"* and that it is a continuous process– "*allows it to change."* Teacher J summarized these responses and introduced a new concept "*computers learn using data.*." She talked about the different types of data and presented examples on slides to help students visualize these different types. She first introduced the new concept and then used the slides from the curriculum resources to further build on it. By

weaving multiple student responses and the content from the curriculum, she gradually built their understanding of each new concept that was introduced.

She did not feel comfortable with a lot of the activities and curriculum resources due to her lack of familiarity with the content. In her interview, she talked about how she did not understand how to facilitate learning through many of the activities in the curriculum because she was not convinced about the concepts that they were meant to address as she was not a content matter expert, and the activities did not have enough guidance for novice AI teachers:

"Again, sometimes I think I wasn't able to explain AI very well. So maybe if the teacher did have a little more guidance. When we started getting to examples of what is AI or what is not AI, sometimes I wasn't sure if they were or not. We aren't experts on it. When you are trying to explain or teach it, a little more scaffolding "

Instead, she leveraged her strength of leading classroom discussions and facilitated learning by eliciting student answers to the questions and then introducing the new concepts after gauging their level of understanding at that moment. She guided student thinking by asking these questions and modeled how to critically think about AI concepts.

Teacher K, on the other hand, used classroom activities, curriculum resources, and the researcher on-site's assistance as the main mediators to facilitate learning. She introduced a couple of AI concepts together using the slides, and instead of asking questions from the curriculum resources, she relied on classroom activities to help students get involved with the content. These concepts included "*AI computers learn and make decisions,"* "*They learn through data,*" and *"How computers get data, let's think about how animals and humans get data."* After introducing three new concepts she posed her first question to the class, "*how do they get this data?*" She got a few responses like "*books," "google,"* and "*other adults.*" She acknowledged these responses, but instead of building on them, she moved on to an activity to delve deeper into how humans use their senses to get data: "*We're going to play a game, with make-belief scenarios to help us think about how humans get data. Once we see how humans get data, we can see how computer scientists mimic these processes in computers. The best ideas come from nature. We are going to create groups for this activity."*

She was comparatively more comfortable using the curriculum resources like the videos and activities to facilitate learning. There are two factors emerging from her feedback interview that can be attributed to this: One, for activities that had underlying AI concepts she was not too confident about, she used the researcher-on-site's help to clarify the area of confusion:

> "This is the part where we had to ask her (the researcher) a lot of questions and she had to study and answer them"

Two, she was more comfortable depending on the videos and the activities because she wasn't the only one talking, and sources of information were distributed, and this helped when she was not too confident about her AI knowledge:

> "I loved the little bits of information because me being you know..a little uncomfortable with it but also it's not me talking the whole time..I learned something new as well"

We observed how Teacher K introduced new concepts from the curriculum, and instead of having conversations about these concepts, she engaged the students in activities to further understand these new concepts by leveraging her strength in science teaching.

Community

In Teacher J's classroom, the community members included the students and the teachers. However, in Teacher K's classroom, there was an additional member, a researcher from the curriculum development team who assisted the teacher with resources, co-teaching AI concepts, and answering student questions.

Rules and division of labor

Teacher J's classroom was more teacher-centric where the conversations were mostly initiated by the teacher and the interactions were between the teacher and the individual students. There was not much student-student interaction unless the classroom activity required them to work together.

In Teacher K's classroom, there were more classroom interactions between the students. Even when they were engaged in a discussion, we observed students building on each other's answers, agreeing with or disagreeing with each other's responses. It was more student-centric and the teacher encouraged students to express their freedom with how they decided to take part in an activity. Students walked around and enacted the scenario from the activity in their groups.

Learning outcomes

We analyzed the pre-and post-test scores quantitively. There was an overall increase in the average scores in the post-tests across both classrooms in comparison to the pre-tests. Paired t-test scores for all the comparisons for two out of three of the constructs were statistically significant ($p<0.001$). Cohen's d values for the first two content areas were >1.0 across both classrooms indicating a large size effect with no differences between the classrooms.

Discussion and conclusion

Teachers' instructional strategies and practices play a critical role in helping students engage in conversation and build an understanding of the content being taught. Our results support the notion that the same curriculum with the same set of resources and materials can be taught in different ways depending on an individual teacher's teaching practices and strengths. Although the PrimaryAI curriculum had multiple resources, activities, videos, and discussion questions, our findings revealed that while one teacher relied more on the discussion questions and slides as resources to mediate learning, the other used more of the activities and the videos to do so. The presence of an onsite researcher who had content matter expertise in the second classroom (Teacher K), helped her leverage curriculum resources that addressed AI concepts she wasn't too sure of. While Teacher J in the first classroom did not have this support, she used her years of teaching expertise to her strength and used guiding questions to mediate learning. The interaction in this classroom was almost always initiated by the teacher, but it was not didactic. Instead, it was more inquiry-based, helping the students to think critically about the AI concepts one at a time. Pre- and post-test results revealed that there was a considerable gain in students' understanding of AI concepts across both classrooms, indicating that there are multiple ways to teach a pre-designed curriculum. The two teachers leveraged their strengths to ensure that the outcome was met. Activity theory, with its emphasis on mediation, provided a useful lens for identifying what these strengths were and how the classrooms were viewed as complex systems. Contrasting classroom cultures could be visualized with the help of the framework and let us identify the different social and cultural interactions that took place between the teachers and the students. Teacher interviews helped us recognize ways in which we can refine the curriculum by adding support for the teachers and provided us with their perspectives on how they and the students interacted with the curriculum. The curriculum offered multiple resources, activities, discussion questions, and additional material to teach each AI concept that was introduced which provided the teachers with the choice of working with whatever they were comfortable with and best suited their teaching styles. Unfamiliarity with the content led to both teachers not feeling confident about explaining many of these concepts.

Both teachers in this study discussed challenges with the content matter they had to deliver highlighting the need to prepare teachers through professional development courses. Further future research should explore how to build teachers' capacity and capabilities for AI education, which includes pedagogical knowledge and understanding of AI and AI ethics. Future efforts could also be directed towards understanding how these strategies to support teachers with AI knowledge can influence teachers' outcomes such as confidence and motivation, and hence impact student engagement and learning outcomes. This program highlighted teachers' experiences and challenges while teaching an AI curriculum providing researchers with the opportunity to develop teacher development programs to address these challenges and improve the curriculum.

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