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RESEARCH ARTICLE

A Cybernetic Guide to Implementing AI for Collaborative Learning: A Synthesis of Four Studies Conducted with Adult Learners

Shantanu Tilak
Center for Educational Research and Technological Innovation, Chesapeake Bay Academy, Virginia Beach, VA 23462, USA

Abstract This paper synthesizes four studies conducted at a special education independent school and affiliated liberal arts university with teachers, senior high school students, and college learners 18 and up, focusing on applying AI to (1) design course blueprints, (2) create comic strip assignments, (3) mediate interactive Socratic discussions, and (4) use learning data to assist students with disabilities in mathematics classes. Gordon Pask's cybernetics is used to visualize interactions to show how AI acts as a component in emergent networks of minds in motion. The four sets of results, taken together, showcase how to implement principles of cybernetics in designing AI-mediated collaborative classrooms. Five out of six configurations of AI's collaborative use outlined by Mike Sharples that the author's research program has so far explored are presented through the four study scenarios and tied back to grey areas carved out by experts in AI education research concerned with design and implementation, classroom relationships, and assessment. Implications of current progress in the principal investigator's research and further directions yet to be undertaken in implementing a series of subject-specific educational scenarios to utilize AI as a collaborative coach are discussed. Practical suggestions to shepherd effective AI-mediated curriculum design, classroom problem-solving and information acquisition, as well as nimble student evaluation are provided.

Keywords AI, special education, AI-mediated collaborative learning, cybernetics

1 Introduction

The development of AI that can respond to human input in writing, images, task-specific templates (Grado, 2024), or even sound and speech has created new human–AI interaction trajectories (Blau et al., 2024; Vander-Auwera, 2024). The advancement of AI has been compared to the path of the web's development (Sharples, 2023). Originally designed for narrow tasks, scaling AI revealed emergent properties useful to perform an array of tasks. The web, similarly designed for basic information retrieval, amplified by search engines was scaled to support social interactions (Brin & Page, 1998; Tilak et al., 2023). Comparing AI with the Internet, Sharples (2023) outlines possibilities for a paradigm of AI usership that facilitates collective intelligence and knowledge exploration.

Sharples' vision is intuitive, owing to the dominant focus in studying human–AI systems being analyses of one-to-one prompt interactions (Sabzalieva & Valentini, 2023; Sharples, 2023). Per an international state-of-the-art review of AI education research published in *TechTrends* conducted by 47 expert researchers in the field (Xiao et al., 2025), extant inquiry has largely focused on small samples and spanned short periods of intervention investigating the effects of AI-mediated learning. Studies suggest that AI may have the potential to spur individual learning, stimulate collaborative conversation (Do et al., 2022; Haqbeen et al., 2022), and reduce teacher workload (Walkington et al., 2024). However, the revolution of generative AI (GenAI) has emerged at a blistering pace, leading practitioners to be overwhelmed while trying to grasp how to incorporate new tools into their practices. Accordingly, reactions among practitioners and researchers have ranged from apprehension to optimism. These reactions can be tempered by exploring grey areas in AI education research through practical efforts.

Xiao et al. (2025), through a collective writing inquiry carried out by 47 experts in AI-mediated

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Shantanu Tilak (✉)
E-mail: stilak@cba-va.org

education research, identify nine categories of grey areas of inquiry, including: (1) administrative decision-making about using AI, or AI orchestration, (2) ethics of using AI for students and teachers, (3) appropriate use of GenAI for assessment and providing autonomy to students, (4) impacts on teaching and learning in terms of teaching purpose, classroom relationships, student cognition, and personalization, (5) uncertainty around AI policies, (6) data collection and use in AI-mediated collaborative teaching and learning settings, (7) ownership and intellectual rights associated with AI output, (8) human agency in human–AI interactions, and (9) partnerships between public and private institutions in utilizing AI.

In this paper, the main foci of concern are classroom practices from the student and teacher lens. Appropriate scenarios to use AI in the classroom for teaching and assessment, ethics associated with using AI output, impacts of AI-mediated collaborative teaching and learning on student and instructor social cognition, and techniques in modulating the role of learners and teachers in human–AI interactions are discussed. The grey areas that relate to aspects of AI education research and practice directly concerned with student and teacher experiences are (2), (3), (4), (6), (7), and (8). This study thematically subsumes these six interrelated areas of inquiry into three broader categories.

The decision to use AI in classrooms is informed by its affordances facilitative of particular learning trajectories (Tilak, 2023). These affordances include providing cold, hard facts as a tutor (McGrath et al., 2025; Tarc et al., 2024), helping students create multimedia artifacts in varied ways independently [as illustrated by grey area (3)], and prompting agentic human conversation, problem-solving, and independent work, as illustrated by grey areas (4) and (8). These affordances can help create engaging classrooms, but also spur sociocognitive change that cultivates value in protecting intellectual property and responsible AI use, as illustrated by grey area (7). Understanding how to use AI for assignments as a tool and not a crutch (for students), being transparent about using AI for simple tasks, and inferring levels of AI use to grade (for teachers), can help create ethical and effective classroom scenarios, as illustrated by grey areas (2) and (3). Teachers can use data generated by AI to gain insights about how chatbot conversations or prompts ensue, and subsequently improve their curriculum design and AI-mediated collaborative activities, as illustrated by grey area (6). All the six interrelated grey areas, (2), (3), (4), (6), (7), and (8), broadly pertain to the design and implementation of learning activities.

Sociocognitive impacts of AI on classroom learning [as illustrated by grey area (4)] do inform design, but mainly concern themselves with information acquisition and collaboration. Human agency and autonomy are intertwined with these mechanisms, as illustrated by grey areas (3) and (8). In producing sociocognitive transformation, AI acts as a mediator between students and teachers (Stracke et al., 2024), fundamentally changing classroom relationships in ways dependent on activity design. Changes in cognition and behavior can be measured through ethical and institutionally approved data collection [as illustrated by grey area (6)] by researchers, teachers, and sometimes students acting as co-designers of AI-mediated classroom activities. This paper implements the notion of co-design through its use of participatory action research methodologies.

How teachers use data and assignments produced using AI to evaluate and assist students [as illustrated by grey areas (3) and (6)] can also be tied back to assessment in the classroom. In grading students, teachers can gauge if their use of AI respects intellectual property and academic integrity, as illustrated by grey areas (2) and (7). Students' agency in creating AI-mediated work can become a barometer for assessment, as illustrated by grey area (8).

Broadly, the goal of tackling the six overlapping grey areas related to student and teacher experiences would be to create a paradigm of AI use that augments but does not replace human learning and problem-solving (Cukurova, 2024; Sharples, 2023). As contemporary researchers pave a path for future research in a rapidly developing technological milieu (Xiao et al., 2025), this paper aims to outline efforts to tread down it that draw from educational psychologist and cybernetician Gordon Pask's work (Pask, 1975). Cybernetics is a transdiscipline investigating how living and artificial systems change in reaction to their environments. Real-time observation and reflection to iteratively craft collaborative education was one of the goals of Pask's research in cybernetics (De Zeeuw, 2001). Sharples (2023) asserts that elements of Pask's cybernetic design approaches could be used to study and design contemporary AI-mediated collaborative educational scenarios.

This paper synthesizes four studies at a university-affiliated research program involving the use of AI in collaborative educational settings using elements of Pask's (1975) and Sharples' (2023) arguments. Practical pathways to overcoming grey areas in AI-mediated collaborative education pertaining to design and implementation, assessment, and classroom relationships are presented (Xiao et al., 2025). Each study uses Pask's cybernetics to create flowcharts that expose how stakeholders use AI to mediate instructional scenarios. Sharples' (2023) work on assigning specific roles to AI in collaborative settings allows the creation of simple guidelines to curate learning configurations and helps further contextualize how each study scenario tackles grey areas outlined in earlier sections. The four studies deal with providing responsive feedback to high school special education students in difficult classes, shepherding college students to create multimodal comic strip assignments, setting up interactive AI-mediated collaborative discussion activities, and adding efficiency to curriculum design procedures for teachers using language models.

1.1 | AI as a Mediator in Collaborative Learning

Pask (1975) developed the idea of scripts that could be used to support collaborative interactions, such as a theatre script, political manifesto, and today, even language models (Sharples, 2023). He created learning technologies that could adaptively evaluate how a learner navigates a set of concepts. His work, implemented in the early days of personal computing (Pask, 1975 & 1976), before AI was operationalized at full scale, foresaw possibilities for artificial agents to be somewhat conversant through their mathematical capabilities (Sharples, 2023). Sharples takes Pask's views and situates them within the current context to build an AI-mediated conversational medium. In this medium, human and AI can be embedded in a reflexive conversation, as opposed to isolated human–AI pairs, as shown in Figure 1.

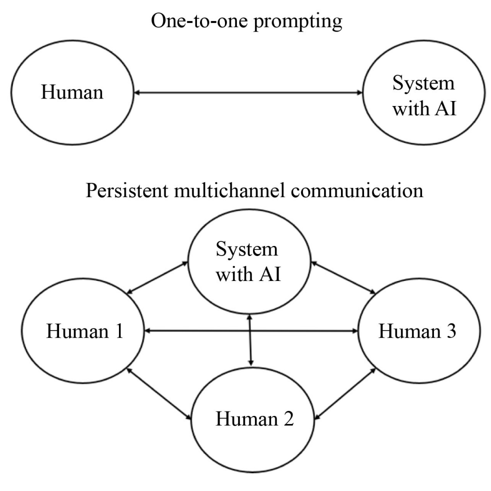

Figure 1 One-to-one prompting and AI-mediated collaborative scenarios.

Sharples (2023) and Sabzalieva and Valentini (2023), as cited in a recent UNESCO publication, jointly identify six roles that AI could adopt in collaborative learning. These six roles illustrate practical ways to embody Pask's cybernetics in AI-mediated collaborative classroom: (1) **possibility engine**, helping generate alternative ways to look at information, (2) **Socratic opponent**, helping participants consider varied perspectives in a discussion, (3) **co-designer**, helping create artifacts and design ways to present usable information, (4) **exploratorium**, helping analyze, develop, and present insights from data, (5) **storyteller**, helping humans tell a story encompassing varied experiences that can be undertaken in our world, and (6) **collaborative coach**, assisting groups in problem-solving through information and guidance.

This paper outlines four studies that started as a response to Sharples' (2023) call to utilize his role-based AI-mediated framework, curating the use of specific AI technologies in specialized learning and design tasks. Elements of Pask's cybernetics are used to describe how AI can take up five of these roles in AI-mediated collaborative learning, drawing from four studies that have so far been completed as part of the author's university-affiliated research program. The role of the collaborative coach does not form part of the scope of this study. It is outlined as a future, more targeted line of inquiry that the principal investigator will carve out, owing to the broad scope of application of AI tools in mediating subject-specific project-based and inquiry-based tasks.

1.2 | Gordon Pask's Cybernetics: Applications to AI-Mediated Collaborative Education

Conversation theory (CT) is Gordon Pask's cybernetic approach to designing and studying the mechanisms at play in structured machine-dependent and independent collective activities such as classroom learning. Pask later expanded CT through an approach known as the interaction of actors theory, which focuses on understanding the progression of potentially endless conversations. As part of his applied research, Pask created analog and digital technologies, housing subject-specific scripts to support participatory learning environments (De Zeeuw, 2001). Tools such as the Course Assembly and Tutorial Environment (CASTE) were used to teach probability to British technical college students, suggesting that responding to learners' needs in the moment helped regulate uncertainty (Pask et al., 1973). CASTE was operated by a teacher in a separate room and consisted of a control interface for students to operate, mounted with light bulbs representing connected concepts (Pask, 1975). Demonstrations and oral answers would be evaluated, and teachers would activate light bulbs as students navigated the curriculum.

Learning environments Pask designed were structured out using analytic distinctions relying on CT's mechanical (M)-individual and psychological (P)-individual nomenclature. M-individuals are systems with physical or material presence, such as brains, living organisms, computers, and notebooks. P-individuals are ideas, rule systems, and patterns of thinking embodied in M-individuals. The analogy between M- and P-individuals is like hardware and software. One M-individual can embody several concurrent P-individuals, and several M-individuals can also embody a single P-individual together, as shown in Figure 2. For example, one student can concurrently think about several concepts, and several students can collaborate on a single problem-solving task. Sometimes, a computer can house software to support collaboration and become enmeshed in the network of humans.

P-individuals can be interrelated. For example, a person thinking about how to draw a circle using a 360° compass maneuver (embodied by one of the hands and a tool) on a plane (embodied in a piece of paper) would need to know how to explain each term with respect to the other to perform the act of drawing a circle on paper. The paper and instrument would augment the individual's actions and create a heuristic to repeat the task, as shown in Figure 3.

Just as humans produce P-individuals, machines can be designed to retrieve information, respond to users, support interaction, and store concepts. To create an automated conversant, relationships between P-individuals can be programmed into a language or "protologic" (Pask, 1984). Apart from programming, the M- and P-individual nomenclature can be used by social scientists to structure out and design basic flowcharts or blueprints of technology-assisted or human-to-human educational scenarios (De Zeeuw, 2001; Pask, 1979; Tilak et al., 2024a). Visual depiction can expose the structure of an activity, possible sociocognitive mechanisms of collaborative learning, and help a researcher design any scenario to be productive (Pangaro, 2008). Sharp and fuzzy methods can be used to analyze data emerging in these systems (Westermann, 2018). Both those designing, and those undertaking activities within the system can collaborate as participant observers.

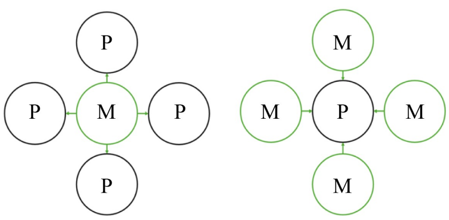

Figure 2 M- and P-individuals.

The roles AI can take up within an educational setting outlined by Sharples can be operationalized using CT's M- and P-individual nomenclature. While frameworks like Sharples' and design approaches like Pask's guiding how to use AI in educational settings have been conceptualized (Blau et al., 2024; Halpin, 2025; Mishra & Oster, 2023), there is no consistent use of these frameworks in current literature. Despite academic inquiry emerging at a rapid pace, contemporary scholars remain unsure about AI's role in education (Xiao et al., 2025), saying it is hard to use a "black box" like AI, which one cannot fully understand, in a learning setting. However, the "black box" metaphor is central to cybernetics research (Tilak et al., 2022), which focuses on the relationship between input provided to, and the output produced by the "black box", and what it means in terms of creating and recreating ways of being in context.

2 Current Article

In this paper, four empirical studies conducted at a university-affiliated research program focusing on the use of AI in high school, college, and teacher education settings with participants aged 18 and up, are synthesized and situated within Pask's CT. The four

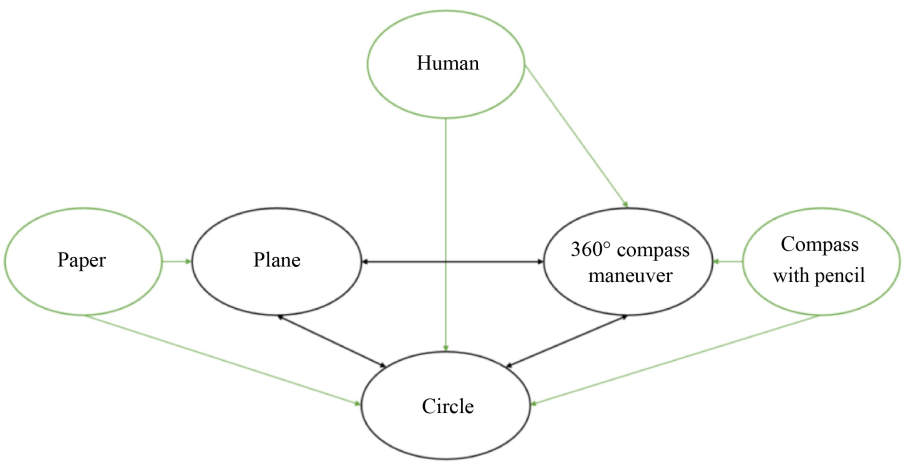

Figure 3 Circle drawing task. Green bubbles are M-individuals, and black bubbles are P-individuals.

studies give practical effect to Sharples' (2023) vision for AI's use in collaborative education, which takes influence from Pask. The synthesis of these studies tackles grey areas in AI-mediated education outlined in contemporary research pertaining to student and teacher experiences (Xiao et al., 2025). One research question is tackled: *How do collaborative human–AI systems supported by complex conversational feedback loops pave the way for responsive technologies to serve new externally mediating roles in educational settings?*

Each study is interpreted in terms of the roles played by AI, and its purpose in tackling grey areas in design and implementation, classroom relationships, and assessment in AI-mediated education.

3 Methodology

Results of four studies involving AI-mediated educational scenarios are synthesized within Sharples' (2023) six-part framework of a social paradigm of human–AI systems and visualized using Pask's M- and P-individual nomenclature. Qualitative and quantitative methods of analysis are used in varied ways in each study (e.g., qualitative: narrative inquiry methodology, quantitative: single case trend analysis, network analysis) to decode mechanisms at play in each scenario. Responsive learning technologies are described in terms of the roles they were assigned by collaborating human agents in each learning environment, including possibility engine, Socratic opponent, co-designer, exploratorium, storyteller, and collaborative coach.

Five roles (possibility engine, co-designer, Socratic opponent, exploratorium, and storyteller) have been explored, owing to the emergent nature of the research program, which will progress into understanding AI-mediated problem-solving in virtual reality (VR) spaces during 2025–2026 (AI as a collaborative coach) through a series of studies. This initiative will be synthesized in a separate study.

Participants in currently completed research efforts outlined in this paper span from high school seniors (18 years of age) to lifelong teacher learners (30+ years of age). Technologies used facilitate text-to-image tasks (CoPilot, DeepAI, Canva Magic Media, Fotor, Shutterstock AI, and OpenArt), Socratic discussions (Character.ai, DeepAI), curriculum template and content creation (MagicSchool.ai), and domain-specific computer-adaptive problem-solving tools (here, ALEKS in a mathematics classroom) (Tilak & Bogacki, 2024). Each set of results is tied back to grey areas in current AI education research, pertaining to design and implementation, classroom relationships, and assessment (Xiao et al., 2025).

4 Study 1: MagicSchool.ai—A Possibility Engine and Co-Designer in Curriculum Creation

Study 1 (Tilak et al., 2024b) involved using the MagicSchool.ai language model, which has been used by over two million educators to develop content and differentiate instruction. Only a handful of basic studies have been conducted to investigate MagicSchool.ai's use (Grado, 2024; Walkington et al., 2024). Other writings about MagicSchool.ai have focused on the potential to heighten efficiency with curriculum design and customize content. Study 1 adds to this literature by explicitly recounting conversational processes in team-based curriculum design conducted in interaction with MagicSchool.ai. It shows how teacher collaboration can be mediated by MagicSchool.ai's lesson plan generator to design and modify curricular blueprints for practical use.

4.1 | Participants and Study Context

The team participating in the study worked at a special education school. The study was approved as a professional development project by the affiliated liberal arts university's institutional review board (IRB). Participants were engaged in designing curricula for a middle school special education online school called CadetNet, assisted by serious games and VR. Three teachers who taught mathematics, language arts, and science, the head of school, and a researcher who taught social studies (80% Caucasian, 20% Asian) acted as participant observers. All five participants had at least a year's experience in using GenAI models, having experimented extensively with ChatGPT and other language models since 2022. A four-week curriculum design workshop was held. The co-observers created one draft lesson plan in each core subject each week, by interacting as a group with the MagicSchool.ai language model and iterating upon prompts to produce a satisfactory draft. Each subject teacher edited MagicSchool.ai's output and created a final lesson plan to implement.

The main focus was understanding whether MagicSchool.ai's lesson plan generator could incorporate and restructure feedback from a practitioner accurately, heighten teacher efficiency, and help create practically applicable lessons (as a possibility engine and co-designer).

4.2 | Data and Analysis

Proposed conversational flows were described by the research staff member to the teacher team using a blueprint to follow during the four-week workshop. The blueprint (as shown in Figure 4) was prepared using Pask's cybernetic principles.

Three qualitative data sources were used. The first source were recordings of the four meetings held during the month-long AI-mediated collaborative curriculum design workshop. Conversations between the head of school, researcher, and teachers, and the process through which they prompted and re-prompted MagicSchool.ai as a group were transcribed on Microsoft Teams and checked by undergraduate research staff. The draft lesson plans developed in the group brainstorming sessions for each core subject and the individually edited lesson plans created by each of the four teachers were collected to understand what changes each teacher made to the AI drafts. After the workshop was completed, the co-observers who created the four lesson plans were asked to reflect on the process using a rubric asking them about how they collaborated. Five rubric questions were provided, including: (1) How did you prompt MagicSchool.ai with the group? (2) What differences did you see in the output produced based on the nature of the prompting? (3) What feedback did the group have about the draft lesson plan produced by MagicSchool.ai? (4) What were your comments on this draft that you made individually when working on it? (5) What changes did you make to your draft to create your final lesson plan?

In this paper, a narrative inquiry (Connelly & Clandinin, 1990) of meeting recordings and rubric responses is reinterpreted to understand how and why MagicSchool.ai served the role of possibility engine and co-designer. Additionally, the results of Study 1 in the grand scheme of uncharted areas in AI education research, pertaining to curriculum design and implementation, and classroom relationships are also highlighted.

4.3 | Abridged Results

Each of the four lesson plans was developed, first, as a draft version through group work, wherein participants explored ways to create practically applicable instructional plans. One topical lesson plan was created and finalized for each subject during the workshop, and teachers edited plans developed by the group for their subject individually. This protocol for collaboration was followed over four weeks. The AI-drafted social studies lesson was brought to the meeting as a primer for the group before the formal process commenced. When teachers reflected on techniques used in the workshop to create the initial lesson drafts, they appreciated the collaborative culture of problem-solving:

"As a group, we used MagicSchool.ai to cooperatively plan 6th-grade lessons in science, language arts, and mathematics. As the science expert on the team, I chose phases of the moon because I had taught this lesson multiple times over six years, and I knew what main factors needed to be included in the AI-drafted lesson plan."

The teachers chose topics they were comfortable with to begin the process and understand how to utilize MagicSchool.ai to create their lessons and in post-workshop editing activities. In this way, they gradually integrated the tool into designing their final blueprints. They either started prompting in a general manner or with the specifics, depending on how they wanted to go about creating and modifying an AI-generated curriculum template. The language arts teacher began prompting broadly:

"I wanted to begin the process very broadly at first to give everyone an opportunity to contribute and

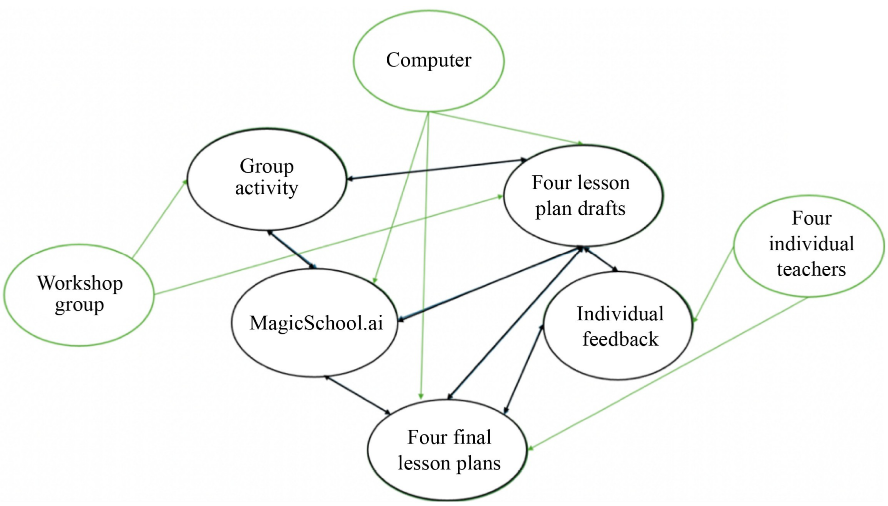

Figure 4 Conversational flows in curriculum design workshop. Green bubbles are M-individuals, and black bubbles are P-individuals.

evaluate the AI results at the start. I had worried that getting too into the details and content specifics on the first prompt would make the results too narrow and exclude collaboration."

The mathematics teacher took on a more specific approach in the session during which a ratio and proportions lesson was created, since she knew the elements she wanted to incorporate into her initial draft. She simply wanted assistance in designing templates from AI:

"I was pretty specific in what I wanted the lesson to include, and I felt that the output matched it pretty well. In fact, I didn't really see that the output added much to my lesson, other than maybe the structure of it and making it look pretty."

However, while the mathematics teacher initially felt there was little to add to the lesson she initially prompted, both she and the language arts teacher ended up considerably modifying the MagicSchool.ai lessons. They solidified the idea that humans in human–AI collaborative systems should take agency to understand how AI-generated products could be practically used. These insights are pertinent to issues of curriculum design and implementation in an AI-mediated educational context. The mathematics teacher suggested it would have been ideal for the language model to make more specific adaptations to the lesson that she had to implement herself:

"I also realized that I did not have it geared towards a virtual classroom, so I asked it to do that. I felt like it added the word 'virtual' to the lesson. I would have loved for it to, maybe, pull in videos or other content I would not have to go find myself."

However, the language arts teacher shared another perspective, saying that education-based language models had not yet been developed to understand the role of context and personal experience in differentiating instruction:

"Honestly, I think it's one of those things that maybe AI is not as capable at this point. You know, we know our kids, we know what their learning differences are like. We are going to be the ones who have to like, add those modifications and accommodations to the lessons."

Overall, Study 1's results show that MagicSchool.ai can easily produce and reproduce output, presenting multiple possibilities for implementing lesson activities by responding to teacher's prompts. The tool can work even in a team environment to co-design a curriculum at the lesson and unit level. However, when it comes to curriculum design and implementation in practice, teachers play a key role in transforming AI output to have practical significance and meet the needs of their students. The process followed in Study 1 shows that interdisciplinary teacher relationships in creating and recreating AI lesson plans can enable multiple perspectives to mesh in prompting and content generation, resulting in usable lesson plans that teachers can modify for their use.

5 Study 2: Text-to-Image AI—A Possibility Engine, Storyteller, and Co-Designer in Storyboarding

Study 2 describes the use of text-to-image GenAI to create intertextual assignments through student–teacher feedback-based collaboration. Intertextuality is an important skill for college students to express themselves using varied media, such as visual, architectural, structural, auditory, and written modes (Bickmore & Christiansen, 2010). Extant studies have focused on creating multimodal assignments to avoid plagiarism (Hale, 2018), and even implemented AI to create sketches in design classes (Zhang et al., 2023). Study 2 is unique in its application of AI to an educational scenario where teachers and students engage in reflexive conversations to iterate upon AI output and create cogent stories—a challenging task that reconfigures AI's common associations with plagiarism. The use of tools such as CoPilot, DeepAI, Canva Magic Media, Fotor, Shutterstock AI, and OpenArt is described.

5.1 | Participants and Study Context

Twenty-two undergraduate students (average age 19.8 years old; 47.9% Caucasian, 17.3% African American, 8.6% Asian, 4.4% Native American, and 21.8% Mixed Race) part of an introductory psychology class at a small liberal arts university, and their instructor all acted as co-observers. The study was approved as exempt by the university's IRB. The curriculum followed *The science of psychology: an appreciative view* text (King, 2023), and covered concepts related to research methods in psychology, sensation and perception, biological factors, states of consciousness, learning, cognition and memory, intelligence, and human development.

The class worked on two-unit assignments related to chapters in the textbook. Each student submitted two papers or storyboards (AI-mediated or hand-drawn) related to a topic of their choice during the semester.

5.2 | Data and Analysis

The decision to create storyboards was collaboratively developed based on an idea brought by one of the students to the class. The blueprint of interactions among students, teachers, and AI was presented as a process diagram, outlining how students would interact with the language model to create an initial storyboard draft, which the instructor would provide feedback upon. Students took instructor feedback and re-prompted GenAI to create a final storyboard, as shown in Figure 5.

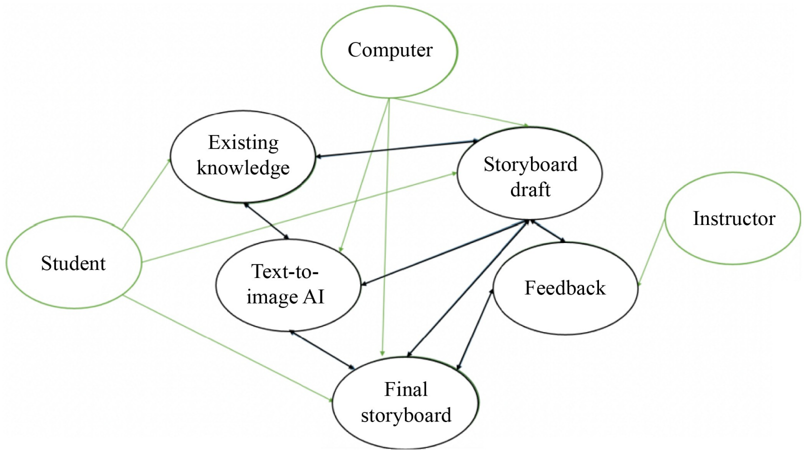

Figure 5 Conversational flows in AI-mediated storyboarding. Green bubbles are M-individuals, and black bubbles are P-individuals.

After assignments were submitted, the process to create each AI-mediated storyboard was narrated by students who created such assignments using a reflection rubric shared by the instructor:

(1) What tool did you use to generate your storyboard?

(2) The next few questions will focus on the process we followed:

a. How did you initially prompt AI?

b. How did you modify the prompts to make the first draft you wanted?

c. What feedback did the instructor have?

d. How did you incorporate it?

(3) What are the challenges and advantages of using AI for multimodal communication?

Students' responses to the rubrics are shared using a narrative inquiry methodology (Connelly & Clandinin, 1990). The ways in which students respond to feedback given by the instructor are described, along with a sharing of victories and challenges encountered. The implications of areas of need encountered by students informed how the instructor shepherded storyboarding activities in subsequent semesters.

5.3 | Abridged Results

Students expressed that photographic principles related to the layout of objects in frames, image processing techniques or styles, and cultural connotations of objects and individuals (e.g., celebrities, and meanings behind objects) were all interacting factors guiding frame creation (Tilak et al., 2024c).

Challenges were encountered during prompting in creating consistent stories. When storyboard drafts did not depict consistent characters, the instructor and students worked together, and students understood how AI might be re-prompted to produce a more cohesive narrative by assigning celebrities as protagonists, or referring to the same character in each subsequent prompt; two minds in motion fed input back into the language model, and co-designed a solution with it from start to finish. Limitations encountered by a student in creating a story based on a consistent protagonist were overcome as follows:

"I would also recommend using a character as the core of your main storyline, so it was consistent and didn't change your character all the time. So, I used Travis Scott to keep the consistency and mood of the character."

During re-prompting, AI also acted as a possibility engine, recreating output to reflect the breadth of the human condition, when students felt that it would not accurately portray individuals from different cultural backgrounds. Another limitation was prompting an addition of text, which was often illegible in AI frames:

"I realized that AI generators were awful at producing texts. After the first few attempts to produce the text I wanted, I concluded that AI could only create illegible gibberish on my images."

Students added words manually to their storyboards after approaching the instructor for a solution. The insights of students shared in this study had far-reaching implications for the design and implementation of subsequent introductory psychology class sections. The instructor shared ways to overcome AI's limitations through prompting with students enrolled in future sections.

AI's broad use as a storyteller to create comic strips had several limitations that were overcome by harnessing its capacities as a co-designer and possibility engine that could work to recreate imagistic output. While some students were concerned about the ethical ramifications of AI art, others who doubted their ability to draw storyboards suggested it could level the playing field:

"I am not much of an artist. Having the power to create a comic strip with the style I wanted, without having to go take art classes, was amazing."

Study 2 displays how intertextuality is a skill that students with varying levels of aesthetic prowess can learn by collaborating with their instructor as equal agents, using the capabilities of text-to-image GenAI and assigning it the roles of possibility engine, co-designer, and storyteller. It also shows how an instructor can utilize AI as an intermediary to support iterative assessment that allows students to improve their work. Lastly, the study illustrates how an instructor uses insights developed by students to improve the implementation of classroom activities in subsequent semesters, turning course sections into interconnected, participatory cybernetic systems. In essence, Study 2 has implications for classroom relationships, design and implementation, as well as assessment.

6 Study 3: Character.ai and DeepAI—Socratic Opponents

In Study 3 (Tilak et al., 2025), a mixed-method approach was used to show how AI-mediated discussion activities with Freud and Piaget chatbots in a college psychology class held on Character.ai and DeepAI led to greater distributed agency and egalitarian participation when compared to business-as-usual discussions held between human agents on the Google Chat platform. Extant literature has shown that using AI to guide Socratic questioning can produce tangential conversations. Studies have also revealed, through static frequency-based measures, that AI-mediated discussions can prompt richer participation and social engagement (Do et al., 2022; Fakour & Imani, 2025; Haqbeen et al., 2022). Study 3 adds a new dimension to existing literature on AI-mediated discussions by turning students into guides of the conversation and by using network analysis to comparatively understand community development in AI-mediated and business-as-usual discussions.

6.1 | Participants and Study Context

Nineteen students and their instructor (35% Caucasian, 35% African American, 5% Pacific Islander, 10% Asian, and 15% Mixed Race), part of an introductory psychology class acted as participant observers in the study. The university's IRB determined the study as exempt. The class section, much like in Study 2, covered the same chapter topics. The modified storyboarding activity from Study 2 was implemented in this class, but the foci of the class research project outlined in Study 3 were AI-mediated collaborative discussion activities. While class discussions were usually held on the Google Chat platform and involved posting a weekly prompt for students to respond to, two of these were held on the Character.ai and DeepAI platforms, to compare community formation processes and the interactivity of conversations. The two AI chats were both held online, during sessions on Freud and Piaget's work. Students were put into four breakout rooms and asked to converse with the two bots related to their theories.

A designated student (called a "driver") took insights from the group to prompt the chatbots, and the instructor hovered between groups to assist. Two business-as-usual Google Chats—one on education and one on the nervous system that occurred proximal in time to the AI-mediated chats were used as comparative data.

6.2 | Data and Analysis

Two data sources were used. The first data were edge lists created from two business-as-usual discussions on the Google Chat platform, and the two AI-mediated chats. The instructor input these into RStudio and used the igraph package to generate network sociograms of all chats. Total conversational turns, word counts, average eigenvector centrality (interconnectedness of agents in the network), transitivity (incidence of three-way talk), and average degree (inbound and outbound interactions) were computed (Kolaczyk & Csárdi, 2014).

Before commencing the project, Paskian blueprints were created for both types of chats and presented to students as shown in Figures 6 and 7.

Qualitative data was needed since edge lists created for AI discussions did not comprise ties formed between each student in each group, but just the drivers' prompting, since this would require recording group activity and pose a possibility to throw off the socially immersive nature of the study. Each group was instead asked, through a rubric of seven questions, to reflect upon group talk:

(1) How did you prompt AI initially to converse with (bot name) as a group? Describe how you conversed to come up with your initial questions to (bot name) in 100 words or more.

(2) Did AI always respond correctly? What did you do to redirect it if it did not? Answer in 50 words or more.

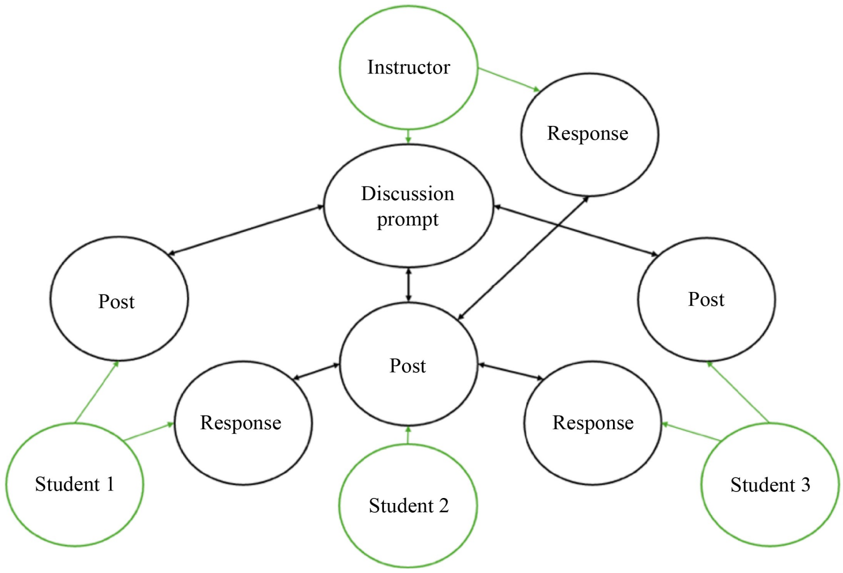

Figure 6 Conversational flows on the Google Chat platform. Green bubbles are M-individuals, and black bubbles are P-individuals.

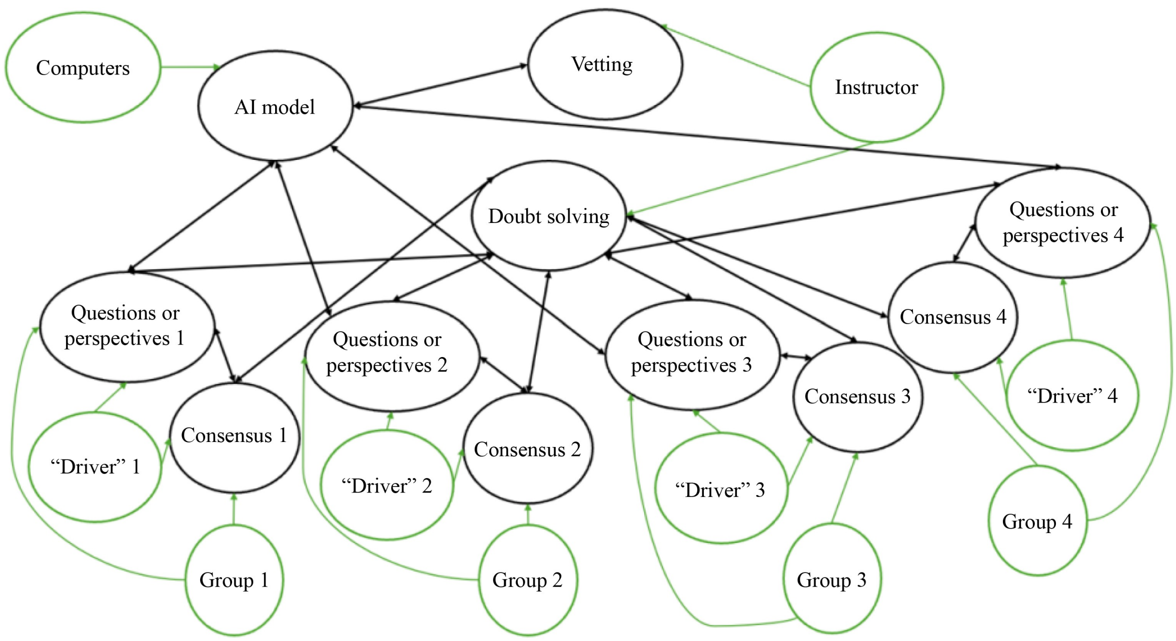

Figure 7 Conversational flows in AI-mediated chats. Green bubbles are M-individuals, and black bubbles are P-individuals.

(3) When you asked (bot name) the discussion prompt, how did it respond? How did you further converse with it after? Describe in 50 words or more.

(4) What conclusion did you reach with (bot name) at the end of the chat? Describe in 50 words or more.

(5) How did the chatbot argue with you, if at all? Describe how it influenced the conversation in a sentence or two.

(6) Think about the weekly group Google Chat we do in class. How is this different? Answer in 100 words or more.

(7) How does adding AI to a discussion activity change it? Answer in two sentences or more.

Group responses to the rubric questions are shared as a narrative inquiry to support network analytics derived from each of the discussion activities (Connelly & Clandinin, 1990).

6.3 | Abridged Results

Network analysis results showed that there was little to no three-way interaction between agents in the business-as-usual chats. Transitivity metrics and sociogram visualizations showed negligible multi-agent talk. Despite only the student drivers' interactions with the chatbots being considered, transitivity was much higher in the AI-mediated chats, owing to a reduction of the total number of possible ties. Eigenvector centrality was also higher because of this reason, indicating higher interconnectedness in the AI chats. The number of conversational turns was much higher in the AI chats as well, due to repeated turn-taking between students and chatbots. Network metrics are provided below, as shown in Table 1. While the number of words in AI chats exceeded those in the Google discussions, this was due to the tendency for the chatbots representing Freud and Piaget to post long responses to student prompts.

Since only the activity of the student driver was presented in the AI chats, the individual eigenvector centrality of each of the student drivers in both chat scenarios was compared to add more consistency to the results. Eight students were considered for this analysis, and each of them had higher eigen centrality in the AI chats, as compared to the business-as-usual chats. A comparison of these values is provided in Table 2.

As mentioned above, the number of edges in the AI networks was reduced owing to the lack of ability to record group talk during AI prompting. Qualitative data was used to uncover groupthink processes. This ensured that the AI chat transitivity and eigenvector centrality metrics were not too positively skewed. Students' insights suggested that extensive brainstorming, and searching of class slides were carried out within each group to come up with cogent prompts to ask the chatbots:

"Our group initially conversed with Freud by asking his own thoughts and opinions to get a baseline for what is to be considered his theory. We conversed to come up with our initial questions by taking points from our slideshow and previous lecture and turning them into specific questions that we were more curious to learn deeper about."

The groups also felt that talking to a chatbot about content covered in class was an effective way to verify cold, hard facts:

"We were receiving information directly from the "real" scientist rather than relying on prior knowledge. He consistently provided thorough answers supported by facts, making it feel more credible since it appeared to come directly from him. It changes by making the content feel more authentic, as if you're hearing directly from the "real" scientist. This made it more engaging for me because it was easy to follow and did not feel argumentative."

Others suggested that both human-led discussion activities and those involving AI as an information provider that responded to Socratic questioning have their own special value. They said that the perspectives of the teacher, which usually would come from a certain standpoint, could also contextualize limitations and strengths of different psychological perspectives.

In essence, Study 3 shows that AI can act as a Socratic opponent that provides facts and a few arguments, but human agents should turn into dominant participants that guide discussions, to avoid tangentiality or bias. The rich content produced by chatbots brings to the fore that AI can be useful to

Table 1 Comparative network metrics

Input topic	Chat type	Total conservational turns	Word counts	Average eigenvector centrality	Transitivity	Average degree
Nervous system	Google Chat	60	1,420	0.246	0.035	3.50
Consciousness	Character.ai	94	2,580	0.630	0.500	4.33
Learning	Google Chat	34	1,159	0.263	0.000	3.40
Development	DeepAI	81	10,338	0.770	0.500	5.67

Table 2 Comparison of individual eigenvector centrality in the business-as-usual and experimental chats

Student number	Non-AI eigenvector centrality	AI-mediated eigenvector centrality
1	0.29	0.54
2	0.25	0.65
3	0.25	0.54
5	0.29	0.65
7	0.25	0.65
8	0.25	0.54
10	0.29	0.65
14	0.25	0.54

provide cold, hard facts to students and help them reinforce their knowledge learnt from instructors through interaction with an artificial tutor. While the instructor became the main guide for the conversation in the Google Chats that each student responded to, more egalitarian participation was seen in each AI-mediated chat group, with the instructor facilitating the conversations of each group and aiding periodically. The student–teacher relationship was altered in the AI-mediated chats to become more student-centered. In terms of design and implementation, the results of the study highlighted how a balance between information provision and discussion was necessary in any good class activity. Plans to add a post-chat whole class discussion to debrief AI-provided data and understand victories or limitations in conducting such chat activities were made for implementation in subsequent semesters.

7 ALEKS—Exploratorium and Co-Designer

ALEKS is an adaptive testing and learning tool. It consists of a knowledge space of topics represented as a pie chart that students can navigate to solve problems. A teacher can view errors a student makes in ALEKS in real-time using learning sequence data.

ALEKS has been utilized in developmental mathematics settings (Thames, 2017), but few studies have comprehensively investigated its use from a sociocognitive perspective. Studies that have investigated its effectiveness have suggested that scores in ALEKS are often correlated with mathematics achievement testing scores (Ayele et al., 2022), and that its use does not negatively affect self-regulation (Park et al., 2024). There is only a sparse body of work understanding its effect on students' confidence with problem-solving in special education settings.

In Study 4, which investigates ALEKS' use, a single case (Kazdin, 1982) approach that taps into the individual variability of students with learning differences is used. Study 4 focuses specifically on students with attention deficit and hyperactive disorder (ADHD), for whom the use of ALEKS may present benefits for learning by providing well-defined directions for problem-solving, as well as a focused interface to learn new concepts, and revise old ones. Study 4 compares how confident students feel about their mathematical ability when the teacher reviews errors and doubts post-class, and in real-time by referring to and responding to emergent errors in a learning sequence using ALEKS' features.

Study 4's goal is to show that in the latter configuration, the teacher can take cues from student interactions with ALEKS in real-time to provide live assistance. The whole mechanism functions like a cybernetic feedback loop (Tilak et al., 2022).

7.1 | Participants and Study Context

The study took place in a high school precalculus classroom at a research-based special education school affiliated with a small liberal arts university that supported around a hundred students from grade one to grade twelve. Two twelfth graders with ADHD (18 years old, data on gender and race is blinded for confidentiality), the only students enrolled in class, consented to study participation, and parents were also informed about study participation. The study was approved as exempt by members of the IRB at the university and an internal review committee at the school.

The class was taught within the Virginia Standards of Learning. Every Monday, students engaged in problem-solving for a weekly topic on ALEKS, which would either involve freestyle problems or a knowledge check to assess skills. Post-class feedback was given about errors in the first half of the semester, as usual. Researchers, students, and teachers decided how to construct a feedback protocol for doubts or errors based on their perceptions of using ALEKS in the first half of the semester. In the second half, it was collaboratively decided that the researcher and teacher would view ALEKS learning sequence data in real-time (errors and correct hits) to provide student feedback when two or more mistakes were encountered. The teacher also created worksheets targeted to the week's topic instead of auto-generated problem sets towards the end of the semester.

7.2 | Data and Analysis

For the first eight weeks, the class ran as usual during ALEKS days, wherein the teacher waited till the end of class to provide feedback. The last nine weeks, however, involved real-time feedback, and the teacher actively looked at ALEKS learning sequence data to detect errors and assist students.

A conversational blueprint of the real-time feedback configuration, as shown in Figure 8, was developed by the classroom research staff and shared with all stakeholders, who agreed to the processes to be followed.

The post-class and real-time conditions were marked as a binary variable (0,1), and this marker was used to delineate trend graphs by baseline and experimental condition. A researcher sat in all 17 classes and recorded fieldnotes about problem-solving. At the end of class, the students filled out an adapted Internet self-efficacy scale (5-point Likert scale),

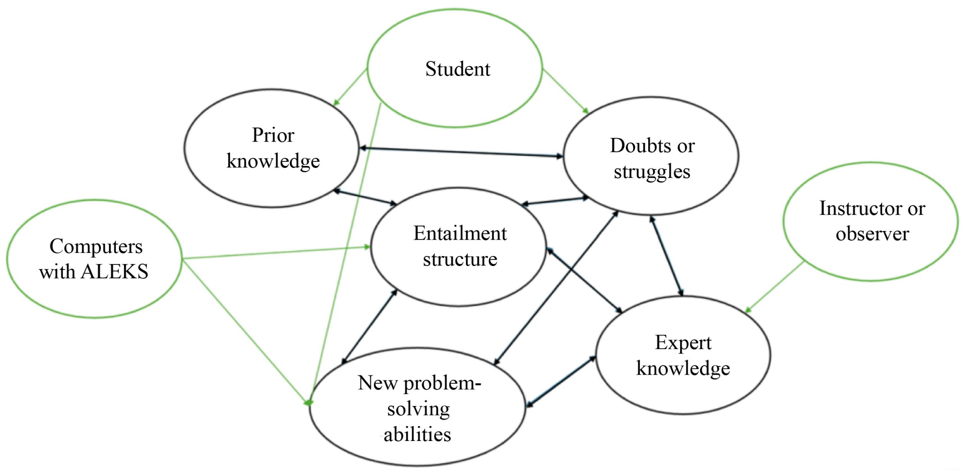

Figure 8 Conversational flows in ALEKS-assisted classes. Green bubbles are M-individuals, and black bubbles are P-individuals.

focusing on the use of ALEKS for problem-solving (Kim & Glassman, 2013). Responses to the question below were analyzed using a trend graph for each student case:

"Using ALEKS, I can organize how I think about the precalculus content and use it to answer harder problems that it gives me."

At the end of the semester, a focus group was conducted to ask students whether reviewing errors and doubts in real-time benefited them, and about areas of improvement with implementation. Fieldnotes and focus group responses were elaborated alongside survey graphs using a narrative inquiry (Connelly & Clandinin, 1990).

7.3 | Abridged Results

During the first eight weeks, there were rises and falls in conceptual differentiation self-efficacy depending on the strengths of both Student 1 [mean (M) = 2.75, standard deviation (SD) = 1.03] and Student 2 (M = 3.37, SD = 0.74). Since both participants were strong at drawing and visual art, graph-related topics were accompanied by rises in conceptual differentiation self-efficacy in terms of individual problem-solving.

During the real-time feedback phase, in the last nine weeks, similar spikes were seen for more visual topics such as conic sections, but there was greater stability and magnitude in conceptual differentiation self-efficacy for individual problem-solving for both Student 1 (M = 3.44, SD = 0.52) and Student 2 (M = 3.80, SD = 0.46). This could have arisen from the fact that the teacher began to solve doubts that students had in real-time, like a cybernetic feedback loop, by viewing errors in ALEKS learning sequence data. Understanding why each student was making errors with certain problems, the teacher would immediately follow up with a short interaction to help resolve doubts. This may have led to greater efficiency in problem-solving and stronger self-efficacy for both Students 1 and 2.

During the focus group, students were explicit in sharing the benefits of using ALEKS. They suggested that the ability to have hints to solve a problem, coupled with teacher assistance in real-time could help them feel a sense of security when solving problems:

"The thing I like about ALEKS is that it provides explanations for a topic or if you keep getting it wrong."

When combined with the teacher's real-time assistance, this capability of ALEKS was viewed as an instructional support by students. Learning sequence data allowed teachers to use classroom data (with ALEKS as an exploratorium) to better help them in real-time. Based on the focus group, teachers, students, and researchers decided to add structure to the ALEKS-assisted sessions by dividing paper mathematics binders to match ALEKS topics, and to make searching for solutions to doubts easier. Data and verbatim insights from experiences with ALEKS were not only used to create a real-time feedback mechanism and customize homework mid-semester, but also to redesign the following semester's class, thus helping the mathematics teacher refine her practice, with ALEKS as a curriculum co-designer.

In essence, Study 4 suggests that using ALEKS to mediate student–teacher interactions can change classroom relationships, turning the teacher into a nimble on-demand problem-solving assistant. It also adds a robust data-driven mode of assessment to a teacher's repertoire of tools that can be used to evaluate student's competence iteratively. Short sessions on ALEKS every week can help reinforce students in their familiarity with problem-solving. The structure of an average week, or how it is designed and implemented by the teacher is altered, with these short ALEKS sessions becoming a regular focal activity for every unit or topic.

8 Discussion

This paper synthesizes four studies that are part of a research program at a special education school and affiliated liberal arts university. Three diverse but small samples of 2 high-school learners, 41 college learners, and 5 educators are considered to show the applicability of AI to varied educational scenarios. Methods such as narrative inquiry (Connelly & Clandinin, 1990), network analysis (Kolaczyk & Csárdi, 2014), and single case trend analysis (Kazdin, 1982) are used. Through its synthesis, this paper shows how Pask's M- and P-individual nomenclature can be used to visualize and design AI-mediated collaborative educational activities. The four studies become practical examples embodying 5 of 6 roles for AI in collaborative learning outlined in Sharples' (2023) recent work, namely the possibility engine, Socratic opponent, co-designer, exploratorium, and storyteller. Future directions to understand how AI can be used as a collaborative coach are outlined in subsequent sections.

The broader goal of this paper is to respond to recent calls to conduct research and explore grey areas in AI-mediated education outlined by Xiao et al. (2025). Six of these grey areas are subsumed into three broader areas for research in this paper, pertaining to design and implementation, classroom relationships, and assessment. One research question is tackled: *How do collaborative human–AI systems supported by complex conversational feedback loops pave the way for responsive technologies to serve new externally mediating roles in educational settings?*

Each study synthesized in this paper shows how to use AI in varied configurations that afford collaborative and individualistic learning, covering grey areas that focus on student and teacher experiences at the sociocognitive level. In each scenario, AI itself, along with the social context, becomes a "black box"; insights from three of the four studies (output from Studies 2, 3, and 4) are used to create subsequent classroom implementation instances (input).

A basic flowchart of the roles embodied by AI tools in the four studies, and the grey areas in AI education research is provided in Figure 9.

Each study synthesized in this paper shows how the affordances of AI tools can help inform decisions regarding their use in any educational scenario (Tilak, 2023). MagicSchool.ai's content generation and modification capabilities, Copilot's and other language models' text-to-image generation, Character.ai and DeepAI's varied personalities that can engage in chatting, and ALEKS' learning sequence interpretation features all informed which of Sharples' suggested roles were assigned to technologies used in each study.

Study 1 expands the basic applied work investigating MagicSchool.ai's use as a possibility engine and co-designer (Grado, 2024; Walkington et al., 2024). The use of MagicSchool.ai in the collaborative workshops allowed teachers to reformulate AI lesson plans based on how they envisioned teaching in their

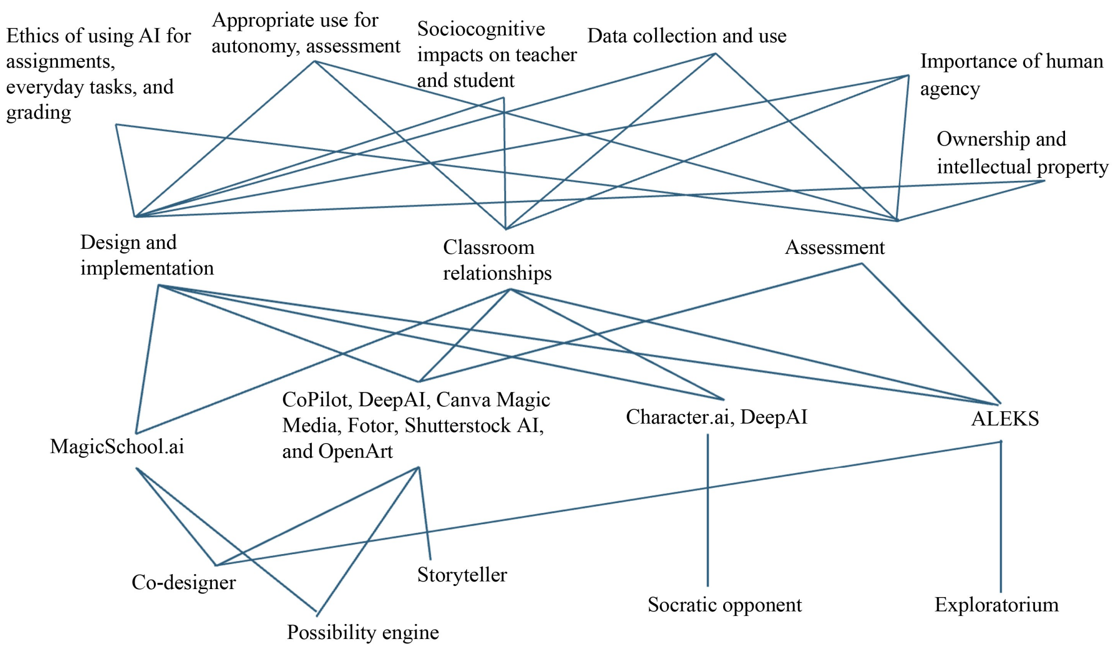

Figure 9 A flowchart of the implications of the four studies.

daily work, influencing teacher–teacher relationships (Xiao et al., 2025). Collaborative content creation can carve out ways for teachers to not only strengthen working relationships, but also help teachers view curriculum creation as an interdisciplinary exercise. Using MagicSchool.ai can personalize a curriculum to a certain extent, but as shared by the teachers in Study 1, they are the ones who know how each student may learn best and should take on the dominant role in influencing the design and individualization process. Transparently attributing AI assistance in curriculum blueprint creation and ensuring that generated content does not plagiarize proprietary materials can help add an ethical dimension to using AI models such as MagicSchool.ai to design curricula.

Study 2 highlights the co-creative potentials of a variety of text-to-image AI tools. It explicitly outlines processes involved in generating intertextual assignments, adding a practical dimension to the notion of using storyboards or comic strips to prevent plagiarism (Hale, 2018), and expands upon studies that focus on designing frames and images by concentrating on narrative form progressing across frames (Zhang et al., 2023). Changes in student cognition and behavior became a key part of the study, which showcased how to use AI to create images to heighten the confidence of those apprehensive about artmaking, enabling them to develop a growth mindset in incorporating feedback to improve their work. Realizing that creating cogent narratives was challenging using AI, students developed heightened agency and autonomy to prompt AI and take control of the input–output process. Students were also mindful to specifically create disclaimers for portrayals of celebrities in their stories and were transparent about the degree to which they used AI to create their assignments. Data from the study was used to redesign the instructor's curriculum in subsequent semesters and improve the storyboarding assignment. In sum, Study 2 tackles grey areas in design and implementation, classroom relationships, and student assessment.

Study 3 adds to existing static frequency-based understandings of engagement in AI-mediated Socratic discussions through its use of network analysis and narrative inquiry (Do et al., 2022; Haqbeen et al., 2022). It also turns students into guides of Socratic questioning that prevent AI-mediated chats from veering in tangential directions. Using AI bots to supplement student conversations heightened student agency and autonomy in the classroom and allowed the instructor to become a non-hierarchical facilitator of discussion activities. The sociocognitive changes produced by AI were evident through the differences seen in network metrics. The creation of small group discussions allowed a higher degree of agency between students, since discussions were usually conducted in a more prescriptive, one-size-fits-all manner using the Google Chat platform. In interacting with AI, students vetted responses using class slides, adding an ethical dimension to the study. Data collected from the study were utilized to alter the discussion activity for subsequent semesters. By creating a collaborative and automated discussion activity that assisted even in curriculum design, Study 3 tackles grey areas in the field specifically pertaining to classroom relationships, and the design and implementation of AI-mediated collaborative educational scenarios.

Study 4 expands current work conducted on ALEKS' use focused on test score correlations (Ayele et al., 2022), and traditional students (Park et al., 2024) through its focus on student self-efficacy in special education settings. ALEKS acts as an ethical helper that prompts and cues hints for student problem-solving and can provide learners with more confidence to grow from their mistakes before the teacher intervenes. Using data from the tool to assist problem-solving can help a teacher act as an on-demand problem-solving assistant, initiating positive sociocognitive change for students, which, in Study 4, was measured by mapping trends in self-efficacy. ALEKS' learning sequence data from a series of class sessions can help a teacher recreate and individualize a curriculum in real-time to match student capabilities. ALEKS also allows provision of computer-adaptive assessments to students that match their current skill, enabling a teacher to set realistic expectations and learning goals. In sum, ALEKS has implications for how a teacher designs and implements a mathematics class, evaluates students, and makes the interplay between students and teachers nimbler through automation.

This paper shows how the use of AI in collaborative learning can create new conversational landscapes in educational ecologies. These landscapes emerge from altering the design and implementation of both individualistic and distributed activities, restructuring classroom relationships, adding automation, as well as new barometers of human agency to assessment protocols.

9 Limitations

Studies in this synthesis focus on four small samples totaling 48 individuals aged 18 and up. The limited scope of generalizability is accounted for through either rigorous mixed methods or rich qualitative data drawn from conversational practices. Study 1, featuring five teachers, uses a rich narrative inquiry of transcriptions from workshop recordings and rubric reflections to share insights. Study 2 takes on a similar qualitative approach to explain processes in storyboarding in a college psychology class. Study 3's sample, similar in size to Study 2's, is ideal for a network analysis, but a lack of recordings of group talk between students in AI-mediated chats called forth the need to use qualitative data. Study 4's especially small sample of two students was limited to a single classroom owing to the high individual variability of special education students. This variability calls for the initiation of inquiry with single case research (Kazdin, 1982). Future investigations of ALEKS' use with students having other learning differences, and even larger classes, would be needed to ascertain whether a real-time feedback configuration has a similar intended effect across the board. It would not be wise to extrapolate benefits for students with other learning differences or for larger classes based on Study 4's results.

All these limitations with sample size considered, nimble hyperlocal examples of student and teacher activity across the four studies allow a basic understanding of how to design and structure AI-mediated collaborative educational scenarios that may be applied, scaled, and adapted in other settings. The four studies demonstrate how educational institutions can use data generated in collaboration with AI to create an internally self-organizing culture of improvement using principles of participatory action research. Such real-time data-driven work was the goal of Gordon Pask's research (De Zeeuw, 2001), which is often forgotten in contemporary educational psychology and technology literature.

While the possibility for AI to be assigned the role of a possibility engine, Socratic opponent, co-designer, exploratorium, and storyteller is considered in terms of effects on classroom relationships, design and implementation, and assessment, this synthesis does not cover the scope for using AI as a collaborative problem-solving coach. The five roles of AI outlined in this paper are more process-oriented, and activities could be adapted and crafted across domains with carefully picked AI tools.

Recent developments in the principal investigator's research program led to access to VR technology embedded with language models that could assist student collaboration in myriad ways in K-12 subject-specific core classes. The scope to apply this set of tools is broad and would not allow brevity in the current paper, requiring a series of studies in subject-specific classrooms with an expansive set of outcome variables.

10 Future Directions

The research program under consideration in this study implements AI-mediated collaborative educational scenarios across developmental levels. Replication of smaller-scale efforts with larger samples for longer periods of time would help overcome limitations with the small case studies and short interventions common in AI education research (Xiao et al., 2025).

Additional work will be conducted by the principal investigator's team to complete their response to Sharples' (2023) call to action for AI education researchers. The CadetNet curriculum designed during the MagicSchool.ai workshop, outlined in Study 1 involves the use of Engage (a VR platform) to offer remote instruction to students with learning differences. VR technology was piloted with fifteen total middle schoolers and a subset of teachers that assisted in MagicSchool.ai-mediated design during the 2024–2025 academic year. Full-fledged research has commenced during the 2025–2026 academic year.

Engage features avatar-based chatbots that can be loaded into its 3D environments. These chatbots can provide facts or even scaffold collaborative problem-solving (e.g., an avatar-based AI model of Shakespeare that can answer questions about archaic English and Shakespearean texts). In the next phase of the research program, a series of collaborative problem-solving scenarios in special education mathematics, science, language arts, and social studies classrooms will be implemented. Both teacher and K-12 student perspectives on the integration of spatial computing approaches with GenAI will assist in co-designing core subject instruction.

While this paper develops insights useful to educators, results may also be fruitful to technology developers or designers (Pangaro, 2008). The ideal scenario would be a redesign of technologies to support affordances that better serve students and teachers in real-time based on study insights. An ambitious direction for the research program described would be to directly involve developers designing and building tools to glean insights from research and implement refined design blueprints. While a few pilot studies involving VR have been implemented by the team to give feedback to technology developers, further efforts to test tools at the laboratory school and university will be conceptualized in coming years.

Pask suggests that distinct forms of social cognition can emerge between each human user and a machine. Therefore, allowing users to generate protocols and heuristics with AI to complete specific tasks could be a long-term goal for designers and developers. Tools that allow building customized heuristics, such as Rabbit R1, may provide ways for students in K-12 and college classrooms to malleably create task-specific AI prompts for their academic purposes in an individualized manner. The functionalities of such tools, which are yet to be formally explored by researchers, may become part of the future directions for the research team's work.

11 Conclusions

Disruptive innovation in educational technology deployment amplifies both hopes and concerns associated with using tools like AI. There are several factors to keep in mind, and strategies to incorporate into designing and implementing AI-mediated educational scenarios that may enhance the experience for learners, teachers, designers, and researchers playing a role in conceptualizing them. Suggestions for practice rooted in this paper's tripartite framework of design and implementation, classroom relationships, and student evaluation/assessment are presented below.

11.1 | Design and Implementation

(a) Firstly, teachers can use AI as a tool to design curriculum templates, basic lesson plan output, and even multimedia content (e.g., songs and stories related to content) but should operate upon the output to ensure it uses valid resources and to fact-check information. Course design blueprints created using AI should be edited to incorporate technology endemic to schools and should accommodate the learning preferences of individual students.

(b) Secondly, multiple perspectives should be exercised in AI-mediated collaborative curriculum creation through teacher co-agency to grapple with a heightened number of design possibilities. Teachers can then operate upon output individually to integrate the views of others into their regular practices and account for their students' experiences.

(c) Thirdly, when implementing AI as a tool to help students complete assignments or engage in problem-solving, it is important to specify the degree to which students should rely on AI output. For example, in storyboard creation outlined in this paper, students were encouraged to create their own captions and initial story narratives. For writing tasks, students should read sources they use, and write up drafts prior to asking for AI summaries. Following this exercise, they should draw out relevant AI output they could benefit from, supplement it with their own opinions, and reformulate the text to fit their natural voices and original arguments.

(d) Fourthly, when implementing AI-mediated discussion-based or collaborative activities, teachers should ensure that groups of humans or individuals become the dominant participants in human–AI interaction, expanding upon insights created in concert with AI. There should always be an interplay between human-led and AI-mediated activities, as shown in Study 3, where AI discussions followed a lecture, and suggestions were made to add a whole-class debrief post the AI chats.

11.2 | Classroom Relationships

(a) Firstly, AI should be used as an intermediary, diversifying the relationship between teacher and student, as shown in Study 2, where feedback provided by the teacher allowed for a modification of storyboards by students. Cold, hard facts provided by AI should always be vetted using instructional materials, as shown in Study 3. In the case of more restricted and pre-programmed technologies, such as ALEKS, as outlined in Study 4, hints should be accompanied by on-demand teacher assistance in case of persistent student error.

(b) Secondly, in collaborative class activities, a decentralized modelling facility should be created using AI that adds efficiency to teacher's facilitation of group work and allows them to hover and assist with doubts or technical issues, as shown in Study 3. Students should always conduct additional research, or look at class resources as they complete such activities with AI's assistance.

(c) Thirdly, in any problem-solving activities, AI should be assigned a role that either provides basic facts or supports problem-solving rather than performing tasks for working groups or individuals, or creating a confirmation bias in speculative tasks.

11.3 | Student Evaluation/Assessment

(a) Firstly, in assessing student problem-solving skills during collaborative class activities, it would not be wise to use more generalized AI technologies to test speculative answers, such as ChatGPT. Tools loaded with specific information pools and data such as ALEKS serve better in this case. Mathematical or fact-based answers may be tested and vetted using AI, but teacher knowledge/class content should always supplement and rationalize AI-generated insights (as in Study 3) about right and wrong so students better understand the "how" and "why" of any concept.

(b) Secondly, in assessing written student assignments that may or may not be produced using AI, teachers should carefully check reference materials and whether arguments are presented in a manner relevant to original sources. Evaluation should be carried out based on inferences of the student's reliance on AI, with the degree of human agency or effort becoming a barometer for evaluation.

(c) Thirdly, in activities relying on imagistic/artistic AI output such as storyboarding, students should be tasked with creating original narratives or prototypes. AI can be used as a tool that promotes iterative feedback-based grading by allowing a student to reformulate or modify their creations with greater ease based on an instructor's advice for improvement.

The most basic postulates of Gordon Pask's cybernetics, namely the M- and P-individual framework, can help structure and refine AI-mediated collaborative educational scenarios add structure to implementing the above practical guidelines. This paper aims to inspire professionals in the field of AI education research and practice to join the cause in opening the "black box", and better understand how AI can create conversational landscapes and new ways of being with technology for teachers, students, researchers, and designers.

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Ethics Statements All four studies outlined in this paper involved obtaining consent from human subjects, and were approved by the Institutional Review Board at Virginia Wesleyan University.

Data Availability Statements The author confirms that all data generated or analyzed during this study sanctioned for public viewing are included in this published article. Individual data points from study participants cannot be shared externally.

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