PATHWiSE: An AI-Assisted Teacher Authoring Tool for Creating Custom Robot-Assisted Learning Activities

Md Anisur Rahman
mrahma46@uic.edu
University of Illinois
Chicago, USA

Isaac Felix
ifeli2@uic.edu
University of Illinois
Chicago, USA

Usman Shahid
hshahi6@uic.edu
University of Illinois
Chicago, USA

Joseph E Michaelis
jmich@uic.edu
University of Illinois
Chicago, USA

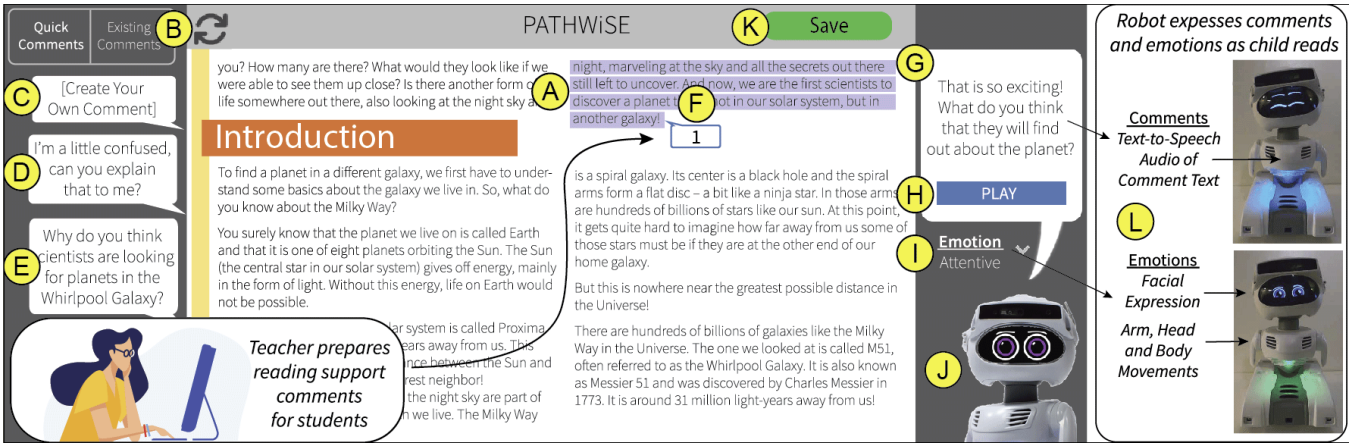

Figure 1: Illustration of a teacher creating custom comments for robot-assisted learning activities utilizing verbal and non-verbal social supports using the PATHWiSE authoring tool (*left*). A learning companion robot delivers the comments and non-verbal emotional displays created in PATHWiSE directly to students during reading sessions (*right*).

ABSTRACT

Social robots can enhance deeper learning through social processes by providing companionship during typically isolated learning activities. Yet, there is limited exploration into the use of authoring tools for teachers to create and customize social robot-assisted lessons. To address this need, we present PATHWiSE, an authoring tool that utilizes teacher-in-the-loop AI-assisted verbal and non-verbal robot interaction design to customize RAL lessons to the needs and strengths of individual students and classrooms. We demonstrate the operation, AI-assist functions, and practical applications of the PATHWiSE UI. Our work underscores the need for developing tools for computing novices utilizing AI and RAL technologies.

CCS CONCEPTS

• **Human-centered computing** → **Collaborative and social computing systems and tools**; **Human computer interaction (HCI)**.

KEYWORDS

social robots, educational robots, AI-powered authoring tools

ACM Reference Format:
Md Anisur Rahman, Isaac Felix, Usman Shahid, and Joseph E Michaelis. 2024. PATHWiSE: An AI-Assisted Teacher Authoring Tool for Creating Custom Robot-Assisted Learning Activities. In *Companion of the 2024 ACM/IEEE International Conference on Human-Robot Interaction (HRI '24 Companion), March 11–14, 2024, Boulder, CO, USA.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3610978.3641086

HRI '24 Companion, March 11–14, 2024, Boulder, CO, USA

ACM ISBN 979-8-4007-0323-2/24/03.
https://doi.org/10.1145/3610978.3641086

1 INTRODUCTION

Socially rich interactions have a significant impact on students' learning experiences [2]. Typically, teachers and other students provide guidance and interaction with students to impart social cues and supports in a conventional classroom. To facilitate these interactions, teachers often draw on their expertise and experience to design learning materials and activities tailored to the class or, at times, individual students, that include unique social interactions that aid students in comprehending and mastering the topics deeply. However, learning activities such as homework, usually performed in isolation, often lack these kinds of personal and social interactions [3]. Social robots can play a game-changing role in these types of scenarios by introducing social interactions to learning activities. These robots can deliver personalized study materials, making homework a highly enjoyable and socially interactive experience [1, 7]. However, creating these social RAL activities most often requires technical expertise that most teachers lack. To address this

challenge, we have developed PATHWiSE, an authoring tool for teachers to create and design personalized robot-assisted learning (RAL) support with no technical expertise needed. It allows teachers to create custom lessons that can be instantly delivered via our learning companion robot system, utilizing the Misty II platform [5]. Each lesson includes custom *comments*, verbal and non-verbal supports, delivered by the robot. With PATHWiSE, teachers can create these comment supports from scratch, use one of several suggested general comments, or generate AI-powered comments using our custom prompting system for GPT-enabled text and emotion generation. In this paper, we provide an overview of the design, technical implementation, and a demo describing PATHWiSE.

1.1 STEMMates Reading Companion Robot

In prior work, we developed a reading companion robot (Fig 1, L) designed to provide *comments*, verbal supports for learning, at key intervals in any reading. Robot comments were created manually using a structured *comment writing guide*, that defined and illustrated how to write comments to support knowledge (*e.g.* providing summaries and supporting vocabulary) and interest (*e.g.* making personal and emotional connections) during reading [10]. We created a library of RAL reading activities as books with robot comments that utilize a trigger-action programming technique. Each book includes a JSON file containing meta-information about the reading, such as reading level, length, topics, and a series of key-value pairs describing the location (trigger) and content (action) of each comment. These key-value pairs provide information for the interaction that identifies *when* a robot should deliver a comment, *what* the content of the robot speech should be, and *how* the robot should deliver the speech including non-verbal emotional displays. With PATHWiSE, teachers can create reading activities with educational articles uploading the article and adding their own custom comments to the article. Articles can be read digitally, where students click comment bubbles placed at in the article to trigger comments, or as printed articles, with comment locations identified by QR-type tags on the page. As readers progress through the article, they can provide verbal responses to the comments, including answering comments posed as questions by the robot, that are automatically audio recorded and delivered to the teacher.

2 DESIGNING THE AUTHORING TOOL

To support teachers in creating their own custom RAL activities, we co-designed PATHWiSE with teachers as a tool with a simple interface that integrates into their existing workflows [8]. Our co-design of PATHWiSE was done through several iterative rounds of design interviews, co-design sessions, and focus groups with teachers to incorporate their needs, workflow, and pedagogical goals and perspectives into the authoring tool to create robot-assisted social learning content for independent educational activities.

The design process consisted of multiple co-design sessions with 13 middle school science teachers, most including recurring teachers in multiple sessions. The first sessions allowed teachers to discuss their current work flow [4] with researchers to identify places where RAL activities might help and how a tool for RAL might be utilized. We then had teachers work in focus group pairs using an online collaborative tool, Miro, to apply custom and pre-made UI elements to shape the look, feel, and operability of a future teacher tool. Based on these findings we created a wireframe of an initial UI to illustrate the design ideas and solicit feedback from the teachers. Finally, we conducted two rounds of user testing with a prototype, where teachers created several comments for science articles using PATHWiSE. Input from the each round was used to revise the UI to incorporate teacher suggestions, specifically providing automated comment suggestions. Additionally, we solicited several rounds of feedback from students about the types of comments teachers created, their experience reading these assignments, and the design of the robot interactions. Our final prototype presented here demonstrates an application of several design guidelines that manifested from this iterative co-design work. Our design guidelines included:

- Allow teachers to *annotate their own content* rather than grapple with unfamiliar new materials.
- Allow teachers to provide guidance for students using *social cues and local context* similar to classroom interactions.
- Present the UI as an intuitive, *simple-to-learn* interface that is not excessively feature rich.
- Allow *optional automation* with teacher-in-the-loop access to suggested and AI-assisted content creation.

3 PROTOTYPING PATHWISE

3.1 Frontend

The PATHWiSE prototype is designed with a straightforward three-column UI layout, specifically tailored for teachers to seamlessly perform **CRUD** (**C**reate, **R**ead, **U**pdate, **D**elete) operations [6]. The left column enables Create operations through Quick Comments and Existing Comments. The middle column serves as a canvas for adding, deleting, moving, and visualizing comments within the reading content, and the right column is dedicated to Update operations, such as editing comment texts, attaching and updating emotions to the comments, playing previews, and saving.

Teachers begin by uploading a PDF of a reading for class that is displayed in the center canvas (Fig 1). Teachers create custom robot comments for articles adding any text they wish by dragging and dropping comment bubbles from the left column onto the center canvas area in three ways:

- **Create Your Own** comments, where teachers write the entire comment from scratch (Fig 1, C),
- **General Suggested** comments, from a list of pre-written suggested comments that can be generally applied to support reading comprehension and interest (Fig 1, D), and
- **AI-Generated** comments, where GPT creates custom suggested comments based on selected article text (Fig 1, E).

General Suggested and AI-Generated comments are developed using comment writing guidelines from prior work (Section 1.1) in four categories: Summary, Vocabulary Support, Personal Connection, and Emotional Connection. Teachers can filter the type of suggested or auto-generated comment displayed using a drop down list. General Suggested and Create Your Own comment options are always displayed. AI-Generated comments are added to the left panel (See Section 3.2) when a teacher highlights a section of text in the article (Fig 1, A) and clicks the generate icon (Fig 1, B). To

add comments, teachers drop comment bubbles on the canvas at the line of the reading the robot should say the comment (Fig 1, F).

Comments dropped on the canvas are displayed as a small comment bubble, annotated with a unique numeric identifier (ID), that acts as an anchor to select, move, duplicate, or delete individual comments. Selecting a comment bubble enables the editing panel on the right column, where teachers edit the text (Fig 1, G) and preview audio (Fig 1, H) of each comment. After each comment is completed (*i.e.* the teacher selects outside of the text editing bubble), each comment is automatically assigned a non-verbal emotional display that is generated using a separate GPT prompt (See Section 3.2) to select an appropriate emotional annotation (Fig 1, I and J). Teachers can edit the emotions manually from a dropdown (Fig 1, I) and preview the display of the emotion on an image of the robot (Fig 1, J). The speech and emotion previews help teachers get a realistic feeling of how an actual robot would deliver the speech to the students. Reading activities are finalized with a click of the Save button (Fig 1, K) from the top right corner of the UI to publish the materials. Each reading activity is added as JSON file of a book in the STEMMates library and students are now able to read each RAL activity where the STEMMates robot will play audio recordings of comment text and display comment emotions (Fig 1, L) as the student progresses through the reading.

3.2 Backend

To support automated suggestions for the comment text and emotions, we use a FastAPI Python server as a middle layer between the front-end and the GPT-4 [11], a large-scale transformer language model pre-trained on billions of text examples created by OpenAI. We send an API request to OpenAI that incorporates the teacher highlighted text from the article into a GPT prompt, based on our robot comment writing guide (See Section 1.1). This way, each AI-generated comment is designed according to the pedagogical standards from our writing guide [10] and applied to specific text in the article. The accuracy and applicability of the AI-generated prompts were evaluated by a team of learning scientists, computer scientists, teachers, and psychologists, with multiple rounds of revisions and edits to calibrate the quality of the outputs. We run four parallel API requests, for efficiency, to create a summary, vocabulary personal connection and emotional connection comment each time a teacher highlights text and clicks the generate icon. The outputs of the GPT-4 request are then displayed as suggested comments on the left sidebar of the UI (Fig 1, E).

During student feedback session on the robot interactions, students emphasized a need to always include emotions with every comment. To support this need, we created an emotion classifier based on in-context learning [9] using GPT-4. Each comment added to the canvas is output as part of an API request that includes training instructions as a prompt to classify the text into an emotional category. The prompt instructions include 103 sample book comments from our prior work that are annotated with human-labeled emotional classifications based on one of eight main emotion categories in Plutchik's wheel, (*i.e.*, anger, anticipation, disgust, fear, joy, sadness, surprise, and trust). The prompt instructions utilize the text completion feature of the GPT-4 language model to append one of these eight emotion classifications onto the text of each comment. The accuracy and applicability of each emotion classification was tested using an additional 66 human-labeled comments, reserved as a test set. We found that our classifier correctly assigns the same categorical label as the human-labeler 62% of the time.

4 DESCRIPTION OF THE DEMONSTRATION

We will demonstrate a proof-of-concept for how teachers can use a UI tool imbued with AI-assisted supports, to create custom RAL activities. A supplemental reading with the robot interaction video will be presented, and visitors can use PATHWiSE to create robot comments for middle school science reading activities, to:

(1) create and edit robot comments using the Create Your Own, Suggested General Comments, and AI-Generated comments.
(2) add their own and AI-Generated emotions/nonverbal actions to accompany each comment.
(3) read with our learning companion robot as it enacts the comments they just created for the reading activity.

5 CONCLUSION

We believe that social supports are critical to enhance learning experiences that otherwise take place in isolation. In this paper, we present an authoring tool that empowers teachers to customize robot-assisted learning activities with social interactions personalized to their classrooms. Our approach to supporting professionals such as teachers with an authoring tool for designing custom robot interactions can be applied in other fields and showcases a hybrid human-in-the-loop approach to AI-assisted work. The accompanying demo offers a hands-on experience with PATHWiSE to craft personalized, robot-assisted social supports.

6 ACKNOWLEDGEMENTS

This work was supported by NSF award #2202802. Thanks to Paul Hatch for his work on the co-design and prototype development.

REFERENCES

[1] Agnese Augello, Linda Daniela, Manuel Gentile, Dirk Ifenthaler, and Giovanni Pilato. 2020. Editorial: Robot-Assisted Learning and Education. *Frontiers in Robotics and AI* 7 (2020).
[2] Ulrike Cress and Joachim Kimmerle. 2018. Collective Knowledge Construction. In *International Handbook of the Learning Sciences* (1 ed.). 137–146.
[3] Paul Hatch and Joseph Michaelis. 2022. Making Home…Work: Codesigning Teacher Tools to Support At-Home Learning.
[4] Paul Hatch, Md Anisur Rahman, and Joseph Michaelis. 2023. PATHWiSE: An Authoring Tool to Support Teachers to Create Robot-Supported Social Learning Experiences During Homework. *Proceedings of the ACM on Human-Computer Interaction* 7 (04 2023).
[5] Misty II. 2023. . https://www.mistyrobotics.com/misty-ii
[6] H. Kilov. 1990. From semantic to object-oriented data modeling. In *Systems Integration '90. Proceedings of the First International Conference on Systems Integration.* 385–393.
[7] Hansol Lee and Jang Ho Lee. 2022. The Effects of Robot-Assisted Language Learning: A Meta-Analysis. *Educational Research Review* 35 (Feb. 2022), 100425.
[8] Phoebe Lin and Jessica Van Brummelen. 2021. Engaging Teachers to Co-Design Integrated AI Curriculum for K-12 Classrooms. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21).* 1–12.
[9] Pengfei Liu, Weizhe Yuan, Jinlan Fu, Zhengbao Jiang, Hiroaki Hayashi, and Graham Neubig. 2023. Pre-train, prompt, and predict: A systematic survey of prompting methods in natural language processing. *Comput. Surveys* 55, 9 (2023).
[10] Joseph E. Michaelis, Bengisu Cagiltay, Rabia Ibtasar, and Bilge Mutlu. 2023. "Off Script:" Design Opportunities Emerging from Long-Term Social Robot Interactions In-the-Wild. In *Proceedings of the 2023 ACM/IEEE International Conference on Human-Robot Interaction.* 378–387.
[11] OpenAI. 2023. GPT-4 Technical Report. *ArXiv* abs/2303.08774 (2023).