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"Wait, Wait, Go Back": Investigating Social Supports for Homework During Do-design Sessions with Teachers

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Abstract: Teachers use interpersonal classroom skills to support their students' learning in the classroom, but homework is done in isolation without the affordances of classroom interactions. Here we investigate how a homework tool could empower teachers to utilize their interpersonal classroom skills and provide new ways to support students outside of the classroom. Through three phases of interviews and co-design, we co-designed software for teachers to create their own robot-assisted homework activities. We found that teachers' existing expertise initially led to wrong assumptions about the tool but after viewing an exemplifying stimulus they shifted their mental model of the tool and of homework in general. These findings can help understand (1) how pedagogical expertise may hinder utilization of new tools, and (2) how a catalyst may shift existing perceptions and facilitate the use of new paradigms to support student learning.

Introduction

Teachers utilize *interpersonal classroom skills* to facilitate meaningful social learning for their students. These socially situated interactions can foster interconnected understanding of content and deeper learning through a process of co-construction of knowledge (Miyake & Kirschner, 2014). However, teachers cannot apply these crucial interpersonal classroom skills to learning activities outside the classroom, such as homework which is typically undertaken in isolation. Some existing technological approaches can be effective in supporting social interactions during learning and offer automated differentiation to support students' comprehension and problem solving. But these often require teachers to adapt their pedagogical approaches to the needs of the software which rarely allows the teacher to utilize their existing classroom interpersonal skills or tailor their supports to connect to students' individual and collective experiences. There is therefore a need for software that shifts the paradigm of homework to align with classroom practices, thereby empowering teachers to use their existing interpersonal classroom skills to provide meaningful connections to the material and support deeper learning. Our goal is to facilitate this change in homework paradigms by co-designing an authoring tool for middle school science teachers to provide rich socially interactive guidance to students working at home with a social robot.

Theoretical Framework

Teachers guide students' acquisition and integration of domain knowledge by utilizing **interpersonal social skills** to co-create knowledge between teachers and peers (Miyaki & Kirschner, 2014; Cress & Kimmerle, 2018). Teachers actively support their students' socially situated learning by responsively attending to student questions and misconceptions, prompting verbal reflections on learning, and adapting content to student's learning preferences (Kucirkova, 2021; Walkington & Bernacki, 2021). To scaffold complex concepts and texts teachers also rephrase or simplify content and use interpersonal and informal language closer to students' discourse and receptive vocabulary (Bernacki, 2021). Such socially interactive learning is particularly critical for science learning where the focus is on generating deep knowledge through collaboration and discussion (NGSS, 2022).

Homework is a valuable instructional tool that can enhance students' learning, have a positive influence on students' academic achievements, especially when connected to classwork and tailored to students' individual needs (Cooper, 2015, Rosario et al., 2019). While many teachers are aware of the need for social guidance in the classroom, students are left to complete homework as an isolated activity. Teachers also believe students face issues of inequity in time, technical resources, and support outside of the classroom, which has led to a reduction of assigning homework (Hatch & Michaelis, 2021). Given these challenges to providing at-home learning, it is important to bolster the use of homework by facilitating teachers to integrate their interpersonal social skills.

Social robots are becoming more affordable for at-home and classroom use and have the potential to transform isolated activities such as homework into socially interactive experiences and facilitate higher levels of engagement, thus promoting learning and interest (Balpaeme et al., 2018, Michaelis & Mutlu, 2018, 2019).

Earlier research in this study showed that science teachers felt current online learning options do not adequately support socially interactive approaches to learning (Hatch & Michaelis, 2021) and explored the co-design of a homework authoring tool (Hatch & Michaelis, 2022). We now apply a different lens to the teachers' viewpoints as they developed over time across the research. Specifically, we examine how to empower teachers

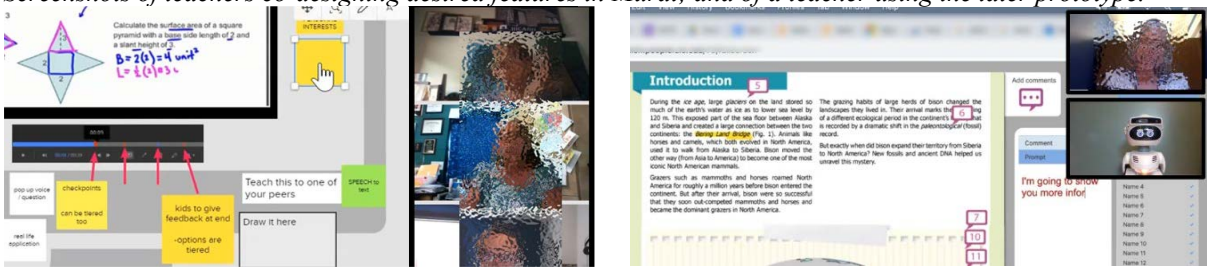
to use their existing interpersonal skills to support students' at-home learning with a social robot: (RQ1) How do teachers' perspectives differ on ways to support their students' learning in the classroom and in homework? And (RQ2) how do teachers' current pedagogical practices impact their application of a new educational technology?

Method

This study stretches over three phases of participatory research with middle school science teachers to elicit their perspectives on providing classroom and homework guidance using a social robot. First, we elicited their perspectives in 1-hour interviews (n=12) on how they currently provide guidance in the classroom and on how they approach homework. We then populated an online whiteboard 'Mural' with a range of digital features based on their views on how they provide guidance to reading assignments. In groups of 2 or 3 (n=7) the teachers then used these digital features to co-design an online tool to meet their needs while we guided and captured the discussions via Zoom (see Figure 2). Teachers indicated their preferences and discussed their reasoning around the features they chose and the layouts they created. These co-designs became the basis for a subsequent working prototype which we then tested (n=13) teachers' use of it to provide support to students doing homework with a social robot. The teachers could add either questions or prompts, 'annotations', to a reading homework article and we explained how these annotations would eventually be voiced by a social robot at home with the student. The 'Misty II' robot used in prior research (Michaelis & Mutlu, 2018, 2019) was also visible to them via the online Zoom window. After the teacher's first or second annotation, the robot voiced the annotations as it would at home with the child. We then asked the teachers to share their thoughts about their impression of this, before prompting them to continue annotating. The locus of this study is not on the eventual student-robot interaction - the focus of previous work (Michaelis & Mutlu, 2018, 2019) - but on how the teachers' pedagogical expertise shapes how they grapple with a software that presents a new way of interacting with students. All three phases were conducted online using Zoom from which we analyzed the captured video and dialogue using a Thematic Analysis approach (Braun et al., 2018) to inductively construct semantic codes and organize the data into major latent codes. We then co-constructed emergent themes through iterative discussion based on meaningful patterns in the data.

Figure 2

Screenshots of teachers co-designing desired features in Mural; and of a teacher using the later prototype.



Findings

We found two major themes across the three phases that pertains directly to our research questions: (1) Teachers feel the lack of interpersonal supports limits the impact of homework and (2) Viewing the robot's interactions appeared to shift teachers' perspectives on the homework activities.

Teachers described classroom activities as rich interpersonal exchanges where they are able to actively guide and respond to their students' learning. Homework was described as an extension of the classroom where students can deepen their understanding of the topic. Many teachers said they use homework as a structured test of their students' understanding upon which to build in classroom activities. However, they also told us they minimized homework as they are not able to provide the kinds of social supports they do in the classroom and expressed frustration at not being able to immediately address issues and questions as they would in person.

When teachers were asked to annotate the homework reading using the working prototype, their initial approach appeared to align with how they had described homework in the preceding interviews. A high majority of the annotations were formed as questions to test the students' understanding of the material, formulated in concise and *formal* language. However, after seeing the robot enact their initial annotations, many teachers appeared to second-guess their original approach and made immediate changes to their original annotations or started new ones that use a *conversational* or socially rich language. Teachers' new annotations appeared to be less like formal test questions and closer to how the teacher would use interpersonal language to support their students' learning in the classroom. This change in the way they phrased annotations seemed to be aligned to

teachers accounting for the student's perception of the robot as a social interlocutor, and teachers spoke about how they viewed the robot as a teacher at home with the student. The teachers' later annotations included ways to prompt verbal reflections, bring emphasis to specific content, and rephrase or simplify complex vocabulary. Many teachers described their later annotations reflected the style of speech they would use in the classroom and greatly expanded the types of annotations to include comments, exclamations, and humorous quips. For example, one teacher's annotation guides the students' attention to a picture, by having the robot say, "Hey take a look at this. Wait, wait, go back, look at that picture again" (Teacher#5), where both content and style appear to be unique to the affordances of social interaction.

In sum, teachers' initial annotations were instructional prompts and formal questions which seemed to be relate to their pedagogical experience with *homework*, but hearing the robot speak those annotations appeared to demonstrate how impersonal those prompts were and inspired the teachers to then create annotations that reflect the interpersonal dialogue they use in the *classroom* to connect with and motivate students.

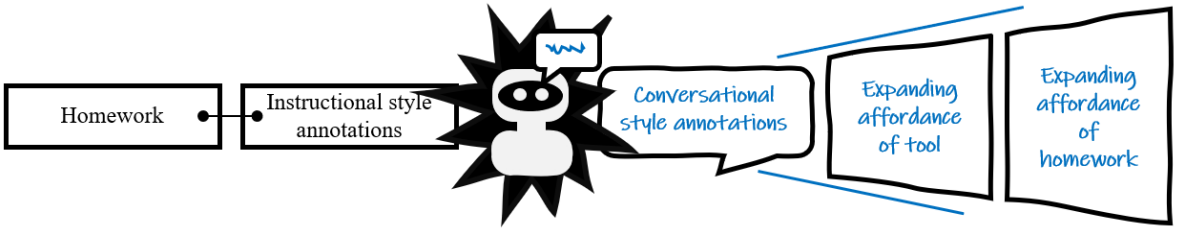
Discussion

At the start of this study teachers described how they utilize their interpersonal skills to socially support their students' learning in the classroom, which contrasts to how they described their approach to homework. However, after hearing the robot say their annotations, the teachers explained -and demonstrated- how they could utilize the robot's social skills to support homework in ways similar to how they described supporting student learning in the classroom. Teachers saw this as an opportunity to facilitate meaningful social learning through homework and thereby attend to student questions and misconceptions, prompt verbal reflections on learning, actively support engagement, and engage with students in relatable ways (Kucirkova, 2021; Walkington & Bernacki, 2021). Their approach changed from preparing homework as an isolated, unsupported task (Cooper, 2015) to preparing it as a new way of interacting with the student and facilitating meaningful social learning (Miyake & Kirschner, 2014).

We also consider that seeing the robot enact their homework annotations may have been a critical catalyst to shift the teachers' mental model of homework activities away from their existing construct of homework, only after which were they able to use their interpersonal classroom skills to augment the homework. The teachers in this study did not immediately use the robot's social capabilities, despite knowing that their annotations would be voiced by it. Every teacher in the study started by creating annotations that resembled traditional homework questions and prompts. We believe it may be that teachers' mental model of the homework activity was initially framed by their prior experience in assigning homework, despite this platform's addition of the robot technology. This mental model appeared to be challenged at the very moment the teachers heard and saw the robot vocalize their annotation. It seems the juxtaposition of the instructional-style writing appeared inappropriate as dialogue and brought their attention to the new *social* purpose of the annotation. The experience appeared to act as a catalyst to abruptly shift the teachers' mental model from a homework paradigm to that of a *classroom paradigm*. This shift in perspective allowed them to tap into their interpersonal classroom skills and create homework activities that mimic student-teacher classroom interactions, rather than a student-paper interaction paradigm. Thus, experiencing the robot enact the annotations seemed to be a critical catalyst for reshaping teachers' understanding of the purpose of the annotations, and shifted their mental model of the affordances of the homework.

Figure 1

It appeared a catalyst was necessary to shift teachers' mental model from a homework paradigm to that of a classroom paradigm and expand their perception of what they could achieve with homework through the tool.



Our study echoed current theory on how complex and challenging homework can require substantial guidance which teachers and parents are often unable to provide (Cooper, 2015). Building on current theory around how social robots provide these important supports (Michaelis & Mutlu, 2019; Balpaeme et al, 2022), we provide a way for teachers to provide robot-student homework interactions that utilize their interpersonal classroom skills, crucial for creating meaningful connections to the material and supporting acquisition of deeper learning (Miyake

& Kirschner, 2014). We also build on existing theory by demonstrating how a catalyst can shift teachers' mental model and thus enable them to draw from existing skills and experiences.

Learning Scientists often engage in changes to teaching practices, therefore consideration of teachers' difficulties in adopting change is essential. Our findings show that it may be important for researchers to find the right *catalyst* to help shift a mental model to take full advantage of innovative new tools. In this study, the teachers' typical instructional style of writing seemed to jar with the spoken voice of the robot, thereby acting as a catalyst for a mental model shift in which they realized the social affordances of the robot. This may suggest that a mental model of an existing teaching practice can be shifted by creating a form of cognitive conflict between old and new paradigms, thereby necessitating the teacher to actively make a change of approach to resolve the issue. Once the mental model has been shifted, the teacher may be able to freely apply their existing expertise within the new paradigm rather than be limited by the constructs of the old one.

Conclusion

In this study, we found how teachers' existing pedagogical expertise with homework hinders their understanding the affordances of a new system, but once their perspective is shifted, the teachers may be able to freely apply their interpersonal classroom skills and facilitate meaningful social learning in the homework. We recognize one major limitation of this study is the small sample size, mostly made up of teachers with significant classroom experience. As such the findings have limited capacity for generalization. While this work uncovered teachers' views based on their emotional and pragmatic needs, future work will include formal testing within the context of real classrooms, and research on how students and families perceive such socially interactive homework.

We believe the findings of this study can help Learning Scientists engage in designing interventions and changes to teaching practices, where adopting change is often of paramount importance. Because a teacher's pedagogical expertise may prevent them from immediate recognition of the affordances of a new approach, it may be important to find the right catalyst to help change existing mental models, potentially enabling the teacher to bring new, expanded insights directly drawn from that same expertise. We believe this work makes important contributions to existing theory and will help guide future work in this area.

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