# STEMMATES: EXPLORING THE USE OF COMPANION ROBOTS WITH SOCIALLY SITUATED INTEREST SUPPORTS FOR IN-HOME SCIENCE READING

A PREPRINT

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February 17, 2021

**ABSTRACT**

Learning and developing interest in academic subjects, such as science, benefit from social interactions during learning activities. Yet, when learning activities are done by early adolescents at home, they are often done in isolation. To provide in-home social learning opportunities for children, our research group has developed a learning companion robot, the STEMMate, designed to read with children, and provide comments throughout the reading to support their knowledge and interest. In our latest iteration of this work, we have developed comments that precisely target supporting knowledge, social connections and interest, and incorporate feedback from prior work and participatory design session to improve the interactive experience. Here we describe plans to understand how children (n = 16; aged 10-12) experience reading science related texts with the robot during a 4-week summer deployment, and explore the capacity of the STEMMate robot to increase interest in science.

***K*eywords** Social Robots · Science Education · In-home learning · Long-term HRI

## 1 Background and Research Questions

Research in the learning sciences has emphasized the importance of social supports for learning [13, 40], because learning is seen as a developmental process that occurs within a socio-cultural context [12], and that cognitive processes and development are supported by interactions with people and environmental artifacts including computers and robots [14, 39]. When learning is a collaborative activity, comprehension, knowledge construction, connection-making and synthesizing new ideas all benefit from distributing cognitive processes and cross-pollination of ideas among group members during social interaction [7]. Each social interactor performs part of the cognitive activity required for comprehension, contributes to new and unique understandings, shapes the way that new information is perceived and interwoven into existing knowledge, and provides a medium for thought and reflection that all aid in deeper learning.

The benefit of social supports are also emphasized in research on long-term individual interest in academic areas [3, 15]. The process of maintaining *situational interest*, higher levels of interest and engagement in a given activity or moment, in ways that promote the development of long-term individual interest is thought to be enhanced through social interaction if the activity gives the learner ways to build relationships and share values in common with others who engage in the practice [2], feel a sense of meaningfulness [33] or social involvement [35], and that they belong among those who do these activities [3, 21]. Social others can support a child's interest in science by suggesting new materials and activities, talking and listening to the child during the activity; interacting with the child and discussing the content of the activity; and emphasizing the value of science and that science learning is important to them [35, 38]. These supports help develop children's interest, because they gain knowledge and skill in science and begin to value science themselves through a natural inclination towards internalizing the values and beliefs of social others [22, 36] and seeing


Figure 1: Example of a science related book, with added April Tag (left) and the Misty II robot platform (right).

themselves as agents and doers of science [18]. In this way, social learning supports, provided continually over time and adjusted based on the child's developmental needs, can promote the development of individual interest in science.

While the benefits of social interactions for learning and interest have been well established, early adolescent children may not receive adequate social support for academic pursuits at home, particularly while reading. Social robots are potentially powerful tools for transforming and *augmenting* isolated in-home activities into a socially situated and personalized experience, and designing robots to supplement in-home learning may be beneficial to promoting interest and learning in science. Children readily interact with robots in a social way [16]. These social interactions can be attributed to anthropomorphism, ascribing human traits to nonhuman entities, based on the robot's appearance [11], and a human capacity for applying social rules and models in understanding interactions [4, 32]. Robot design such as appropriate eye gaze patterns [1], referring to previous interactions [24], and slowly revealing personal characteristics [17, 25] can promote social connection making with the robot. Giving robots names and backstories can also strengthen a human's social reaction to include a higher propensity for empathy and social-emotional connections with the robot [10, 9]. Promoting these deep social connections are critical in establishing a long-term relationship with a robot [25] that are needed to provide continued socially situated learning and interest development support.

### 1.1 STEMMate Robot

To address the need to develop student interest during in-home learning in for middle school children, our research group has developed a learning companion robot, the STEMMate robot, to tailor reading activities to individual children as a summer reading program. In prior work, we have demonstrated how children experience reading with the robot as a deeply social activity, where over time children ascribe emotions and personality to the robot, and that they feel it supports their reading comprehension and interest in reading [26]. In these studies we had focused on supporting reading as an academic activity in itself. In our latest work we explore the potential of the STEMMate robot to improve children's interest in science through a shared reading experience.

At the core of the STEMMate learning companion robot design are reading interactions created with socially situated interest supports based on design guidelines developed in prior work (see [26, 30]). During each child initiated reading session, the STEMMate robot begins with an introduction where the robot greats the child and recaps their previous reading session, including the book and page they had last read. The child may then continue reading the previous book or choose to begin a new book. When the child needs a new book, the robot suggests three options, based on their user profile, and the child is then free to choose any book in the library. Once the reading selection is made, the robot then sets a reading goal, based on their user profile, and the reading session begins. During the reading session, the child reads the book out-loud to the robot and will encounter a scannable ID tag [23] every two to five pages in each book (See Figure 1, left). When the tag is scanned the robot responds with a preprogrammed comment that pertains to the activity in the book. For each tag, preprogrammed comments are written to provide knowledge (i.e., vocabulary comprehension), interest (i.e., value or belongingness), or social (i.e., emotional reactions or personal history) supports to the reader. During an early phase of this project, we have selected 20 science content related books to include in the library, and have developed a comment writing guide for creating social, knowledge and interest support comments explicitly tailored to supporting interest in science.

For this project, we have chosen to utilize a commercially available social robot, Misty II [37] (See Fig. 1, right), that is designed and manufactured by Misty Robotics, Inc. The Misty II robot features an advanced array of features and sensors, including a tread-based drive system, 4K camera for face and object recognition, 5200mAh Lithium Ion Battery, touch panels, and movable arms. This also robot represents a reasonably inexpensive robotic platform that could potentially be purchased by a community-center or other informal science learning program to facilitate guided reading activities with children and has been designed and tested for rigorous long-term use. We believe incorporating this robot into the study will provide an authentic test of a social robot for in-home and informal learning, provide a durable and stable platform to reduce technical problems that may have inhibited interactions in previous studies, and allow for complex social interactions based on high quality hardware options.

### 1.2 Research Questions

In this work, I describe our research group's expansion on the program to assess the feasibility of using a social robot for reading science related books at home to promote interest in science over a four week experience. In this study, I ask two main research questions:

(1) How do children perceive and interact with the robot in authentic, in-home, long-term situations, and how does this interaction change over time?

(2) Does working with a robot designed with socially situated interest supports increase individual interest in science when compared to a pre-intervention baseline?

## 2 Design

To examine children's experience reading science related books with the robot and estimate the effect the robot's comments have on developing interest in science, we will conduct an AB single-case research design [19], that will include a 1-week baseline, the A-phase of the AB design, and a 4-week in-home robot intervention, the B-phase of the AB design. We will recruit families (n = 16) with children aged 10-12 that have low-interest in science to participate in the study during Summer 2021. We will run two sections of the AB study with half of the families participating in the first half of the summer, and the other half participating in the second half of the summer.

Prior to beginning the reading program we will conduct pre-study interviews with each child and their family about their interest in science, interest in reading and their current reading habits. We will also ask children to complete a pre-study *individual interest in science survey*. Children will then begin the A phase of the program by completing a 1-week long reading diary to document their current reading habits. For the B phase, we families will be delivered a STEMMate robot, library of specially tagged science related books for the study, and a connection case that includes a Raspberry Pi computer connected to the STEMMate via WiFi and a Wireless Internet Hotspot. After the study materials are delivered, a researcher will introduce the child and family to the robot (remotely), help them set up the system, and ensure they are able to begin reading with the robot. After a short initial reading session, to establish initial perception of the robot, the researcher will interview the child about the experience and ask the child to complete a robot likeability survey.

Throughout the 4-week B phase, the robot will automatically collect usage and log data as well as audio and video recordings of each reading session, and after each session the child will complete a *situational interest survey*. At the end of each week of the B phase, a researcher will (remotely) visit each family for a short interview about the experience and to troubleshoot or run maintenance on the robot. After the 4-week intervention ends, a researcher will collect all study materials from the family, and then conduct a post-study session that includes a discussion of the experience of reading with the robot, an additional post-study interview about interest in science and reading, and a post-study survey on their interest in science and their perception of the robot.

### 2.1 Measures

Each child participant will complete a pre and post self-report Likert-style survey of individual interest for science (science interest), an intial- and post-study robot likeability survey, a survey of situational interest with two factors triggered (catch) and maintained (hold) situational interest, and provide demographic information including age and gender. Many of these measures have been utilized in prior work in our research program [30, 26, 29] Each survey will be scored as a mean score of all items on the survey. For each survey, we will calculate Crohnbach's alpha, with $\alpha >$ 0.70 as an indicator of reliability [8].

The science interest scale is based on a previously validated reliable measure of individual interest [27, 28], that includes 12 Likert-style items where children are asked to rate their agreement with each statement on a scale of 1 (strongly disagree) to 7 (strongly agree). Examples of science interest items include: "if my science homework is interesting, I will keep working at it even if it is difficult."

The catch and hold situational interest scales are based on a previously validated and reliable measure [20]. We will modify the language of each item to relate to experiences with the reading activities with the learning companion robot, and in some cases make the reading level of the items more age appropriate. These two scales each include 6 Likert-style items on a scale of 1 (strongly disagree) to 7 (strongly agree). Examples of catch and hold interest items include: "the reading activities sparked my curiosity" and "I think the topics I learn about in the reading activities matter to me."

Finally, the robot likeability scale was developed from a survey used in prior work [31] based on the interpersonal judgement scale [5]. This scale includes 14 adjective pair items where children are asked to rate their feelings about the robot on a scale of 1 (first adjective, e.g. unhappy) to 7 (second adjective, e.g. happy). For example, one items asked the child "How bored or excited was your partner?", and they were asked to choose between bored and excited on the adjective pair scale.

### 2.2 Analysis

To assess how children interacted with the robot and perceived their interactions we answer RQ1. We will conduct a grounded theory analysis [6] of interviews from children conducted after their first and last interactions with the robot. Analytic coding will aid in developing themes that emerge from the data to demonstrate how children perceived their interactions and how this changed over time. We will explore patterns in reading habits and books selection based on logged events from the robot and compare these with data collected from the baseline reading diary activities. We will also conduct a time-series analysis [34] to evaluate changes in situational interest during the course of the program that can be compared to other logged events during the program such as high or low reading activity or specific books being read. Finally, we will examine differences in children's responses to the robot likeability scale using a non-parametric Wilcoxon signed rank test.

To assess the effects of interacting with the robot on interest, we answer RQ2. We will conduct a non-parametric Wilcoxon signed rank test of differences in science interest pre and post study and additional grounded theory analysis of child interviews to examine changes in child attitudes over time. We will then use our time series analysis as a predictive tool for understanding the role of fluctuations in situational interest and usage in changes in individual interest. While these analyses are conducted with small sample sizes, the findings will represent exploratory results that can be used as pilot study evidence of feasibility.

## 3 Conclusion

In this work, we hope to explore the feasibility of implementing our STEMMate robot as a learning companion to support science interest through shared reading activities. Based on our prior work, we expect that children will experience fluctuations in the usage and situational interest, and hope that our latest revisions to the interactions and robot comments will sustain both metrics over time. We also expect to find increases in the likeability of the robot and interest in science, although in some cases changes in interest in science may take longer than one month of interaction to measure. We therefore will rely on additional qualitative results to inform our understand of why some children's interest increased while other didn't and to examine aspects of the interaction that may not be suited for this duration of use. We hope this work will contribute to theory and practice on long-term robot interactions for learning.

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