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Noticing Critical Information for Productive Uncertainty Management During Engineering Design Activity

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Abstract: The phenomenon of noticing information is crucial for experiencing uncertainties and influencing uncertainty management processes. This paper presents findings from an analysis of two sixth-grade teams engaged in a collaborative engineering design activity. We investigated how learners notice critical information during the problem-solving process and its role in resolving various uncertainties experienced by the team. Preliminary results show that three factors - mentors' invention, physical artifacts in the environment, and setbacks experienced during troubleshooting enabled crucial noticing processes that engaged learners in productive uncertainty management practices. Based on the findings, we then briefly discuss how to start strategizing scaffolds to help learners notice important information.

Keywords: Noticing, uncertainty, uncertainty management, engineering design, middle school learners

1. Introduction and Background

Wrestling with uncertainties provide opportunities for learners to meaningfully participate in the disciplinary practices (Kaur & Dasgupta, 2019; Manz, 2018). Uncertainties specifically play a crucial role in the context of engineering design. Due to the ill-structured nature of design tasks, engineers experience uncertainties about different aspects of the design problem all the time during the design process. For example, due to unclear objectives, analysis, and evaluation of multiple solution alternatives, and troubleshooting issues (Dym, Agogino, Eris, Frey, & Leifer, 2005; M. E. Jordan & McDaniel, 2014).

Planning related to which uncertainties should learners must experience, and when and how should they experience these uncertainties can help learners engage in core disciplinary practices effectively (Manz, 2018). For experiencing such productive uncertainties that can engage learners in the disciplinary content and practices, it is first important that learners notice critical information relevant to the task that they are solving. This information could be certain concepts, scientific principles, or relationship between different variables involved in the task (Chase, Malkiewich, & S Kumar, 2019). Lobato et al. (2012) defines noticing as a process of actively selecting and interpreting relevant information. A given situation can contain enormous information to be perceived by the learner. Noticing affects how situations are perceived and interpreted and therefore shape learner's judgement and decisions (Chase et al., 2019).

This preliminary work focuses on investigating how learners notice critical information relevant to a given design task. Particularly, we seek to understand how noticing is related to learners' uncertainty experiences and the progress that they make during the design process while collaboratively resolving an engineering design problem. Thus, in this paper, we explore following research questions - (a) What factors trigger noticing processes when learners collaboratively solve an engineering design problem and (b) how does noticing affect teams' uncertainty management processes?

2. Methods

The data came from a study which was conducted with the broader aim of understanding middle school learners' uncertainty management processes in collaborative settings. We conducted a four-day study (approximately an hour each day) in a sixth-grade classroom in a large public school in an Indian metropolitan city. We analyzed data of two groups of sixth grade learners. Group A consisted of four participants (three males and one female), and Group B also consisted of four participants (two males and two females). Teams were given a design task of building a balloon powered toy and asked to maximize distance and ensure that vehicle travels in a straight line. For details refer (Kaur & Dasgupta, 2022). Two primary researchers were present in the class as observers along with three teaching assistants (TAs) from the same department. TAs handled the audio and video data collection and also mentored groups from time to time

For data analysis, we first transcribed the video data of the teams and identified uncertainty episodes using a coding scheme developed by Jordan et al., (2014). We analyzed learners' discourse in these episodes to analyze how they notice critical aspects concerning the expressed uncertainty. For analyzing data, we followed inductive and interpretive approach and methods of interaction analysis (B. Jordan & Henderson, 1995). The unit of our analysis is "individual in a group" (Hogan & Fisherkeller, 2005). The authors then engaged in elaborate discussions to resolve the conflicts and reach consensus.

3. Findings

We will now describe how two prominent factors identified during our analysis helped learners in noticing critical information about the problem being solved and the role it played in their uncertainty management processes.

3.1 Role of mentor intervention

We observed that for Team B, Mentor (TA) played a key role in triggering the noticing processes among the team members. For most of the time during the design activity, this team was led by one of the team members named Anmol. He majorly took decisions on behalf of the whole team and other team members readily agreed with him. However, in one of the episodes he alone decided to use a 10mm straw as nozzle. The other team members had previously struggled with the uncertainty regarding which nozzle straw is appropriate for their design, however no body objected or questioned Anmols' decision.

At this point, the TA intervened and asked Anmol why he chose that specific straw, to which Anmol confidently replied, *"Because more air will come out of it [10mm straw] and if we use it, it [toy vehicle] will go for a longer distance"*. TA probed him further asking if *"more air"* or *"less air"* would help them in maximizing their vehicle's distance. This counter questioning by TA elicited doubt in Anmol's mind regarding whether his reasoning is correct or not and he started wondering about his decision. After this moment, other team members also started expressing their viewpoints. Opposite to Anmol's view, other team member, Anu, reasoned that to enable vehicle to travel longer distance, the 8mm straw would be better as, *"air will come out slowly slowly and it will go far."* Another participant, Krish, added to Anu's response saying that "speed" of the air coming out of the straw would also matter.

This episode clearly showed that TA's deliberate interruption and counter questioning helped Anmol notice that he does not have sufficient understanding for making the decision alone. He started accounting other team members' input which eventually initiated discussion among the teammembers. Since the team members had positioned Anmol as the decision maker of the team, they ignored the uncertainty they were struggling with before. However, after TA's intervention, they noticed that the person they positioned as a decision-maker also lacks understanding about which nozzle is better for their design and thereafter they all started to pitch in. They began expressing their viewpoints, posing questions, and engaging in argumentation, indicating that they acknowledged the need to address uncertainty as a collective unit and manage it through sense making processes like questioning, argumentation and logical thinking.

3.2 Role of physical artifacts/materials in the environment

Teams were provided with three different sized straws, out of which they had to choose one to use as nozzle for their design. We observed that both Team A and Team B questioned about the utility of the straws and wondered about why they were of different sizes while they explored the material kit provided to them in the beginning. For example, in case of Team A, seeing the straws kept on the table, one of the participants, Sehaj, asked about why different sized straws were given to them. The observable difference among the three straws triggered uncertainty about how the size of the nozzle mattered for their design. This was followed by elaborate group discussion regarding the expressed uncertainty. However, we observed that although materials in the environment can trigger important questions, they are not enough for sustaining productive uncertainty management actions like analytical discussions, critical evaluation, or inquiry processes. Like in this case, another participant Jeet did not shared uncertainty expressed by Sehaj as he thought the size of the straws does not matter and although Sehaj persisted on discussing his uncertainty and even asked for mentor help, the entire team did not delve deeper for resolving his uncertainty.

4. Discussion and Conclusion

This preliminary exploration gave us insights about how mentors' careful and deliberate intervention at the appropriate time and presence of specific task-related materials like the three different sized nozzles triggered curiosity and desirable confusion related to important questions regarding the design problem.

However, it is important that learners are oriented towards the potentially productive information. The analysis showed that learners can perceive same information differently and they do not naturally notice relevant information by themselves. Therefore, there is a need scaffolds learners in a way that they not only notice important information but also find it meaningful. Factors like what material should be provided to the learners, and when and how should mentor/instructor intervene, have to be designed strategically. For our future work, we will dig deeper into the data to find out other triggers of *"noticing"* and more relevant ways of problematizing content for the learners so that they meaningfully notice relevant information and productively use it to manage uncertainties.

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