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An Investigation of Feedback in Engineering Design Workshop for Teachers

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Abstract: Engineering education has gained support in recent education reform efforts in the U.S. Although this is beneficial to students, it has become a significant challenge for teachers who do not have experience in engineering teaching, particularly in under-resourced schools. In this study, we characterized the nature of teacher educators' feedback used in an engineering design workshop. The findings showed that teacher educators frequently focused their feedback on the participants' process, and none of them focused on personal evaluation, praise, or self-regulation – feedback that is common in classrooms. This study suggests the importance of teacher educators reflecting on their feedback during engineering design activities for effective engineering education.

Learning Engineering Through Teacher Workshops

In the United States, the Next Generation Science Standards and several state standards require that elementary students be taught engineering content and practices (National Research Council [NRC], 2013). However, this creates significant challenges for teachers with no experience with learning or teaching engineering. A key element for successful learning is applying what is being learned and continually refining that knowledge (NRC, 2013). Putting teachers in students' shoes helps identify the difficulties and pitfalls students can face in the classroom and helps teachers predict what kind of help the students expect from their teachers (Sargianis et al., 2012). By alternately wearing a student's and teacher's hat, teachers can think about how to apply their experiences as a learner to their classroom as a teacher. The role of a teacher educator in helping teachers think about implementing engineering design instruction during workshops is significant. This is because teacher educators can model teaching methods and feedback, which can be adopted by teachers. Based on this, we developed the following research question: What is the nature of the feedback given by teacher educators during an engineering design workshop?

Methods

This study analyzed video recordings and work products from an engineering design workshop for teachers in rural, low-income elementary schools. The eight participating teachers had an average educational career of 12.75 years, but none of them had experience teaching engineering. Four teacher educators with an average of 13.5 years in teacher education and 10 years in engineering teaching provided the workshops. In the study, teachers were engaged in the engineering design activity named "Save the Penguins" (Schnittka et al., 2010), which asks participants to design a container to keep a penguin-shaped ice cube from melting. Since the workshops were conducted remotely, the videos were recorded and divided into main sessions and breakout room sessions. The data collected from the workshop were organized and analyzed in three stages. The first step was making event maps (Kelly & Crawford, 1997). Second, transcripts were created by selecting the part where the interaction involved feedback. Last, we extracted the emergent types of feedback based on transcript analysis based on Hattie and Timperley (2007)'s four levels of feedback: task (FT), process (FP), self-regulation (FR), and self (FS). FT focuses on immediate task accomplishment, FP on extending thoughts, FR on self-control and commitment, and FS on simple praise. The study's feedback data was initially coded based on emergent types, and both authors met to discuss and reach consensus in cases of disagreement. After finalizing feedback types, the data was analyzed using the constant comparative method (Glaser, 1965).

Findings

In the workshop, feedback from teacher educators was presented in various types, from simple status checks to active scaffolding. First, FP was the most frequently observed type of feedback. Teacher educators encouraged teachers to come up with the next plan, suggested some ideas for further exploration, and asked about the expected pitfalls when they applied this activity to their classrooms. This feedback led teachers to come up with strategies to comprehend the tasks and expand their thoughts, which is more effective than at the task level for enhancing deeper learning (Brooks et al., 2019; Hattie & Timperley, 2007). We also found a connection between teaching experience and the frequency of FP. Walter and Ellen, who have extensive experience in teaching engineering, used the FP much more than other teacher educators. Here, we do not intend to generalize the results, but we infer that more experience as engineering teacher educators might have taught them to use process level of feedback to facilitate teachers' comprehensive learning.

Table 1
The frequency of teacher educators' all levels of feedback

	Walter (18)	Ellen (26)	Teddy (2)	Linda (8)	Total (Feedback)
Task level	8	4	6	6	24 (34%)
Process level	21	12	9	3	45 (63%)
Self-regulation level	1	0	0	1	2 (3%)
Self level	0	0	0	0	0 (-)
Total (Teacher educators)	30	16	15	10	71 (100%)

In addition to FP, feedback at the task level (FT) was also frequently observed, with teacher educators reaffirming information related to the task or pointing out mistakes that teachers were making to prevent misunderstandings about the task. Finally, although infrequently used, teacher educators also addressed teachers' contributions and efforts, mentioning their achievements based on evidence or criteria of engineering design activities, which can be linked to the self-regulation level of feedback rather than simple praise. FS was not provided during workshops.

Implications

Even though engineering education has been emphasized in elementary education, most elementary school teachers have little understanding of engineering (NASEM, 2022). Teachers in rural areas often face challenges in accessing high-quality professional development opportunities, including those related to teaching engineering design activities. Thus, the experience of learning and doing engineering through teacher workshops is essential for them to develop their teaching expertise in engineering. Teachers' engineering experience during teacher workshops can be connected to classroom practices (Johnson & Gil, 2022; Sargianis et al., 2012), so it is important for them to experience meaningful and effective feedback during engineering workshops. Furthermore, feedback during engineering design activities has a positive effect on the classroom environment as well as relationships between teachers and learners (Burnett, 2010). Therefore, this study suggests that investigating feedback experiences that teachers received in engineering design workshops become a cornerstone for future studies on feedback in engineering education for teachers.

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