Teachers' Scaffolding Strategies in Relation to Enacted Verbal Reasoning in the Design Process

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Abstract

Learning to reason in the design process is enclosed in the process of learning to design. Hence, in this study, we explore teacher-student interactions with the aim of describing teachers' support strategies in relation to enacted reasoning in the design process in secondary school technology education in Sweden. The study deploys social cultural theory as a lens, with a focus on scaffolding means and intentions of the teacher. Relevant reasoning in the design process is theoretically framed as means-end reasoning and cause-effect reasoning. Empirical data was collected through three classroom observations with three different Swedish secondary school technology teachers, with subsequent interviews with the teachers using stimulated recall. During the observations the students were engage in different design processes. The data was analysed using thematic analysis, where themes as strategies were constructed for each reasoning type from patterns of meaning in teachers' scaffolding means and intentions. For each reasoning type, teachers employed strategies of decreasing control and increasing control. However, the enactment of these strategies differed in scaffolding intentions and means in relation to what reasoning was verbally enacted. Our findings indicate that teacher-student interactions within the design process in technology education classrooms hold significant meaning and value. This has implications for both teaching and learning in the field.

Keywords

Technology education, Design process, Scaffolding, Teacher strategies, Means-end Reasoning, Cause-effect reasoning.

Introduction

This study is an extension of a study presented at the PATT40 conference (see Hultmark, 2023), where the focus has been elaborated. The present study includes one additional observation and interviews using stimulated recall. In addition, scaffolding has been adopted as a theoretical frame.

In education, the presence of supportive teachers is paramount. Lack of support not only affects learning but also impacts students' confidence and motivation (e.g., Ludwig-Hartman & Dunlap, 2003). This also applies in technology education. The support provided by the teacher can be of different character, and ranges from for example assignments, instructions, assessment, to interactions. Experienced technology teachers emphasize that the interaction with the students is crucial and stress the importance of not leaving the students alone with their learning (Fahrman et al., 2019).

In technology education, the design process is an important content and method (Norström, 2016), which the students are supposed to develop capabilities in relation to. However, the emphasis on learning within the design process varies across curricula globally. In the Swedish context, which frames this study, learning to and about design is in focus (Skolverket, 2022). Within this process, the students must draw successive conclusions through reasoning, moving them forward in the process. Here, reasoning is defined as the process of posing premises to reach a conclusion (Walton, 1990). Therefore, learning to design entails learning to reason within the process, emphasising the significance of unpacking reasoning in understanding design practice (Cramer-Petersen et al., 2019). This emphasis on students' reasoning aligns with global curricula trends (OECD, 2023), underscoring its relevance for both teaching and learning.

However, regarding teaching, this reasoning can be transient, posing challenges for teachers in elucidating it and providing adequate support. For teachers, it becomes a multifaceted task, requiring constant adaptation to students' need and real-time situations (Seery et al., 2023; Sheoratan et al., 2024), including attending to students' emotions (Meyer and Turner, 2007; Siu and Wong, 2014). Nonetheless, there is a need for a deeper understanding of teachers' support in relation to the students' reasoning in the design process.

Background

Teachers' Support

Several theories describe how teachers' support facilitates student learning, with scaffolding being favoured through a sociocultural lens. Scaffolding, rooted in Vygotsky's (1978) Zone of Proximal Development, is described as the tailored support teachers provide for learners to progress in their process. Wood et al. (1976) describes this as the teacher "controlling" what surpasses the learner's current ability, while the learner manages what for them is possible. They further uphold that this is more effective than supporting the learner to complete tasks or leaving them to navigate processes alone. Through the teacher's scaffolding, the learner would later be able to perform the task unaided. Followingly, scaffolding contributed to learning (Stone, 1998).

Teacher support encompasses various actions, making it useful to distinguish different scaffolding. Saye and Brush (2002) distinguish hard scaffolding, which teachers plan, from soft scaffolding, situational support tailored to students' needs. Sheoratan et al. (2024) focused on soft scaffolding, exploring how three teachers scaffolded students' problem solving in design projects within chemistry education, where learning objectives related to both design and chemistry. They especially focused on scaffolding with questions and feedback, identifying that the teachers used more steering support for student actions and more exploratory support for students' thinking.

In recent years, research has been carried out investigating the technology education classroom. Esjeholm and Bungum (2013) observed teacher-student interactions in a design project focusing on technological knowledge. They identified that the teacher support was crucial for the students moving forward in the process. This support was often not in the form of instructions, but suggestions. This can be compared to Goldschmidt et al. (2014) and Kimbell and Stables (2007), who describe the teacher's role in the students' design process as of a guiding nature. Esjeholm and Bungum also identified a shift in the teacher-student interactions during the process. In the beginning phases, the teacher's support was more oriented to assisting the students towards a goal through interventions. Later in the process, the support shifted to more explorative. Svensson and Johansen (2019) also identified the nature of the teacher's support as being in the form of interventions, especially when necessary preconceptions had not been established between teacher and students. Furthermore, Lysne and Esjeholm (2021) identified that interventions and instructions was prevailing in their studied teacher-student interactions in a design project, as opposed to moderative and explorative talk.

Reasoning in the Design Process

Reasoning within the design process is elusive and can manifest in various ways. There are many who have described this reasoning, where recent focus has been on design reasoning as abductive reasoning (e.g., Dorst, 2011). However, the design process involves reaching multiple conclusions through different types of reasoning. Hence, it is deemed that a constant pendulation between different types of reasoning is crucial for process efficiency (Davis, 2011; Razzouk & Shute, 2012).

Research on reasoning in the field of design has been centred around reasoning as deduction, induction, and abduction. Cramer-Petersen et al. (2019) investigated reasoning patterns in idea generation, identifying an abduction-deduction pattern as prevalent. Similarly, deduction, induction and abduction have also been emphasised for technology education (Seery et al., 2023). However, within philosophy of technology, means-end reasoning has been highlighted as essential throughout the process (e.g., Hughes, 2009). Building on this, Hultmark et al. (2024) proposed a model for reasoning in the design process in technology education identifying two reasoning types as relevant, means-end- and cause-effect reasoning.

Furthermore, with the use of yet another theoretical frame for reasoning in the design process, Siverling et al. (2021) identified what prompted students' verbal evidence-based reasoning while working in a STEM integrated engineering design process. Using Toulmin's model (1958) to frame reasoning, they identified teachers' questions or comments containing the word "why" or encouraging evidence use prompted students' evidence-based reasoning. Nevertheless, they identified that any teacher expression sometimes served as a prompt. As can be noted, there is a lack of a common theoretical ground for reasoning in the design process. For technology education, more research is needed relating to students' reasoning in the design process, for the field to consolidate and to explore this important practice in the design process.

Aim and Research Question

The students' reasoning in the design process moves the process forward. That the students get the opportunity to explore all aspects of the reasoning in the design process is important for learning about and to design. Here, the teachers have an essential role of supporting this. However, little is known about this support. Hence, the aim of this study is to describe the support strategies used by the teacher in teacher-student interactions, based on the enacted verbal reasoning in the design process. This has been done by guidance of this research question:

What characterises technology teachers' support strategies in relation to the enacted verbal reasoning in the design process?

Theoretical Framework

We approached the research question with socio-cultural theory as a lens. With regards to the research question, both teachers' support strategies and reasoning in the design process needed to be theoretically framed. Further follows the theoretical standpoints used in this study.

Teachers' Strategies

The teacher's support strategies were framed using a model described by Van de Pol et al. (2010) based on socio-cultural theory and scaffolding. They identified teachers' support strategies as consisting of *intentions* and *means* of scaffolding. The identified three intentions, where:

- *Scaffolding of students' metacognitive activities* include scaffolding of learning of key ideas and providing support for the student to reflect and govern their own learning;
- *Scaffolding of students' cognitive activities* include to reduce the students' degrees of freedom in the task and for example simplifying the task;
- *Scaffolding of students' affect* include to have the intention of controlling students' frustration or adherence to the requirements of the task ;

These intentions were combined with six identified means for scaffolding:

- *Feeding back*: Provide information about performance;
- *Hints*: Suggestions to move forward;
- *Instructing:* Tell the student what to do;
- *Explaining*: Give more information or clarification;
- *Modelling*: Demonstration of skills or behaviour;
- *Questioning*: Ask questions that requires for the student to answer;

In this study, both the teachers' intentions and means were of interest and strategies were regarded as a combination of intentions and means. This theoretical frame governed the data collection method and were used deductively in the data analysis.

Reasoning in the Design Process

To explore the enacted verbal reasoning in the teacher-student interactions, the model for reasoning in the design process in technology education described by Hultmark et al. (2024) was chosen as theoretical framework. This is a flexible model that can be used in various parts of the design process. With philosophy of technology and technology education as a basis, Hultmark et al. describes two different reasoning types as relevant in the design process; *means-end reasoning* and *cause-effect reasoning*. Means-end reasoning is the reasoning from desired ends to means as actions, rendering in intentions to act or actions. Cause-effect reasoning on the other hand is reasoning as evaluation and prediction about causes and effects. Here, the conclusion takes the form of a belief about cause, effect, side-effect, or consequences. Hultmark et al. highlight the relationship between these two reasoning types and upholds that cause-effect reasoning takes place within means-end reasoning. A student reasoning in the design process, would constantly go back and forth between these two reasoning types (see Figure 1).

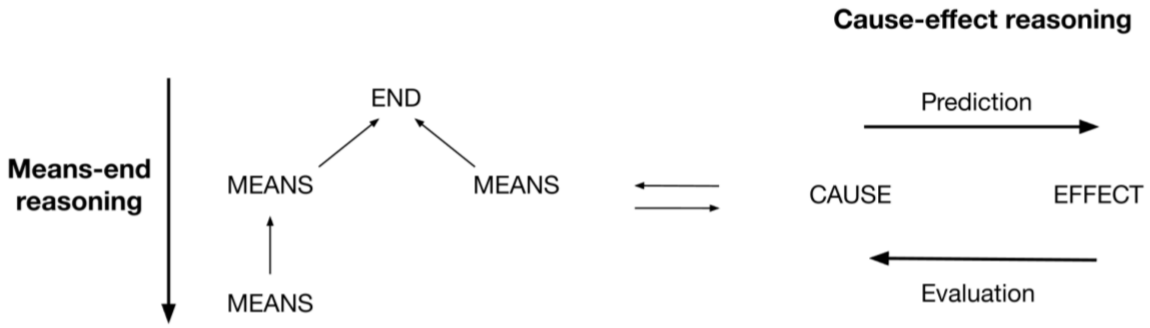

Figure 1 Schematic illustration of means-end and cause-effect reasoning as published by Hultmark et al. (2024)

Method

Data Collection

To be able to interpret and analyse scaffolding means and enacted verbal reasoning in teacher-student interactions, data was collected through observations, and video- and audio recordings in classrooms. Selection of Swedish secondary school teachers was made through a combination of snowball and subjective selection. To capture teacher intentions, the observations was followed by interviews using stimulated recall. The data collection process is presented in Figure 2.

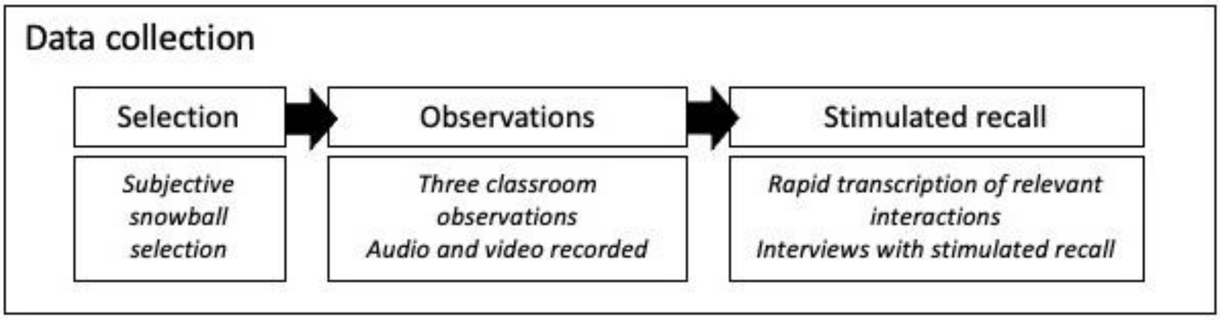

Figure 2 Illustration of the data collection process.

Selection

A combination of subjective and snowball selection (Denscombe, 2018) was used to gather in-depth data from Swedish secondary school technology teachers. Initially, technology teacher educators disseminated information about the study among their networks of teachers. From those interested, participants were selected based on inclusion criteria: secondary school technology teacher planning a design process project within the study's timeframe. Three technology teachers were selected as participants, from now on referred to as Jack, Oscar, and Harry. The teachers then proposed lessons for observation.

The teacher Jack had planned a project tasking students with designing a ventilation system, with the aim of building a model. The students were to use a small DC-motor to power a turbine controlled by a microbit. The students chose a location for which they designed their ventilation system. During the observation, the students had made drawings, and were all building models.

The teacher Oscar had planned a project where the students designed their dream house. Tasks included producing sketches, a floorplan, a three-view drawing, and a written description detailing foundation, walls, and roof decisions. During the observation, students predominantly worked on their drawings, while two were writing.

The teacher Harry had planned a project wherein students designed a small plastic car capable of forward motion using a DC-motor. Documentation was required though a logbook. During the observation, all students were building their car.

Observations

In total, one lesson per teacher was observed, each lasting close to an hour. One researcher participated during the lesson as a complete observer, refraining from interaction with the teacher or students (Baker, 2006), except to address questions related to the study. This approach aimed to minimize the researcher's influence on participants (Denscombe, 2018). However, as Baker highlights, this limited the researcher's ability to fully perceive interactions. Additionally, the multimodal nature of the lesson (e.g., Otrel-Cass et al. 2010) added complexity to the observation. Therefore, data was collected through audio recordings captured by a microphone attached to the teacher and microphones placed near each student group. Furthermore, the lesson was video recorded using two cameras to capture gestures, movements, and relevant artefacts. This approach also ensured avoiding filming none-participating students. Observations involved 17, 14, and 11 students, respectively.

Stimulated Recall

Following each observation, to capture the teacher's intentions in interactions, the teacher was interviewed. Stimulated recall was used to facilitate the teacher's recollection of interactions (Lyle, 2003), enabling them to reflect on their actions (Haglund, 2003). While video recordings are commonly used as stimuli, in this study, transcripts and still photos from videos were used to reduce reactivity. This approach aimed to enhance internal generalisation in interviews by minimising reactivity (Flick, 2018).

To prepare stimuli, audio and video recordings from the observation were manually transcribed, focusing solely on interactions relevant to the research question. The time between observation and interview was minimised to one school week to facilitate the teacher's recall of the lesson. The interviews were audio recorded.

Data Analysis

The data was analysed through thematic analysis as described by Braun and Clarke (2006), allowing for flexibility (Robson & McCartan, 2016) and the use of a combination of theoretical standpoints to identify intersecting patterns of meaning. The analysis process, outlined in phases 1-7 in Figure 3, began with syncing audio and video recordings from the observations using a computer software (DaVinci Resolve). Subsequently, 570 minutes of recordings were manually transcribed, focusing on teacher-student interactions. The audio recordings from the student groups were used when audio from the teacher's microphone was unclear. Interactions considered irrelevant to the research question were not transcribed, such as interactions unrelated to technology education. Additionally, the interviews' audio recordings, in total 147 minutes, were manually transcribed.

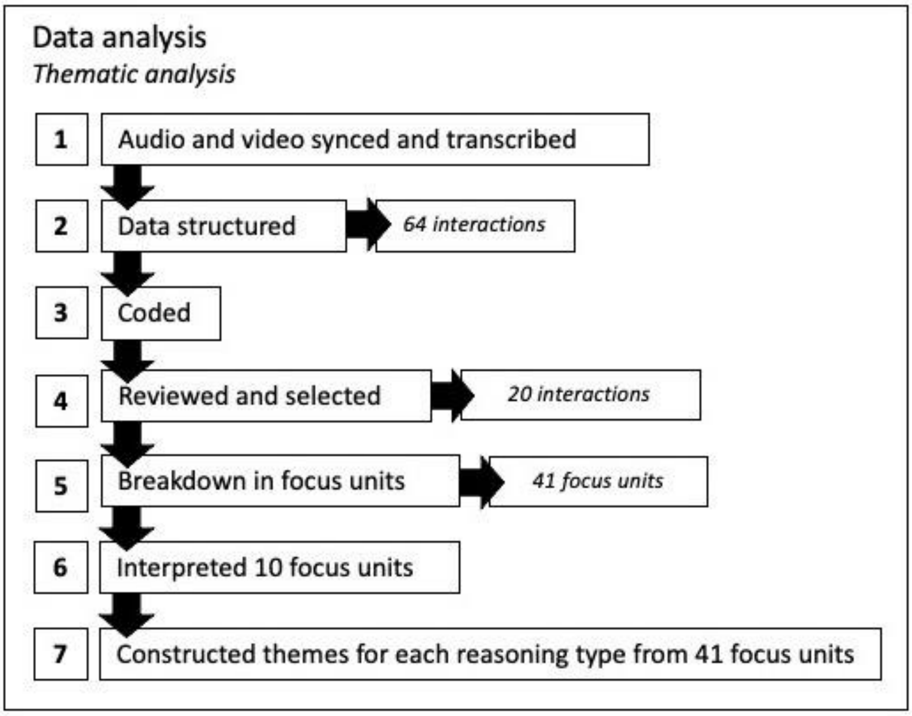

Figure 3 Illustration of data analysis process.

The data was then structured into teacher-student interactions, defined as when a conversation started between the teacher and one or more students until it ended, resulting in 64 teacher-student interactions. Each interaction contained several teacher or student speaking turns, which was deductively coded using the model for reasoning as described by Hultmark et al. (2024). Sections of teacher-student interactions were then coded based on prevailing reasoning type. Subsequently, each teacher turn was deductively coded for means of scaffolding described by Van de Pol et al. (2010), with additional contextual coding. Examples of coding are shown in Table 1. Lastly, the interview transcripts were structurally coded (Saldaña, 2017) using the scaffolding intentions described by Van de Pol et al. (2010), supplemented by inductive coding for deeper understanding and context. The deductive codes used are presented in Table 2.

Table 1 Example of coding of a teacher (T)-student (S) interaction

	Interaction	***Reasoning***	***Scaffolding means***
T	*We have a few weeks, so we actually have some time to be able to test. The tricky thing about this material. What would you say is the tricky thing about this material?*		*Repeats and clarifies that the student has time to test.* *QUESTIONING*
S	*Working with it.*	*Provides EFFECT*	
T	*Well, it's pretty hard to work with, so you get a reason why you don't want to use it. Here we have another material, so we have a few different ones to choose from.*	*Confirms EFFECT* *Suggests other MEANS*	 *HINTS*

Table 2 Codes used in the analysis.

	Means-end reasoning	*Cause-effect reasoning*	*Scaffolding means*	*Scaffolding intentions*
Codes	*MEANS* *END* *MEANS-END* *CONCLUSION*	*CAUSE* *EFFECT* *CAUSE-EFFECT* *SIDE-EFFECT* *CONSEQUENCE* *CONCLUSION*	*FEEDING BACK* *HINTS* *INSTRUCTING* *EXPLAINING* *MODELLING* *QUESTIONING*	*SCAFFOLDING OF METACOGNITIVE ACTIVITIES* *SCAFFOLDING OF METACOGNITIVE ACTIVITIES* *SCAFFOLDING OF AFFECT*

Followingly, each teacher-student interaction was reviewed against the research question. Interactions where scaffolding occurred, and conclusions were drawn were selected for further analysis, resulting in a data set of 20 teacher-student interactions. These interactions were then broken down into focus units, each containing only one conclusion. Focus units containing both reasoning types (7 units) were split, resulting in 41 focus units. Of these, the teacher had reflected upon 31 in the interview, while the researchers interpreted intentions in the remaining 10 focus units based on the 31 units that the teachers had reflected upon and what student the teacher interacted with. Lastly, the focus units were sorted by reasoning type, and themes as strategies were constructed based on shared patterns of intentions and means.

Ethical Considerations

Before data collection, information about the study and data management plan was sent to the Ethical Review Authorities in Sweden for ethical review, who gave advisory opinions about the study. These were implemented in the study. Furthermore, the implementation of the study followed ethical requirements established by the Swedish Research Council (2017). This includes requirement of voluntariness and informed consent. The teacher, students and legal guardians received customised written information about the study before data collection. All participants gave written consent, except from two teachers, who gave verbal, audio recorded, consent. For students younger than 15 years, their legal guardians gave written consent as well. The students who did not participate in the study, attended the lesson in an adjacent room. All data has been stored in accordance with the Data Protection Act (GDPR).

Findings

With the aim of describing teachers' support strategies in relation to enacted reasoning in the design process, two themes for each reasoning type were constructed from analysis of 41 focus units. For both reasoning types, teachers employed strategies involving decreased or increased control. However, the specific scaffolding intentions and means differed between the strategies for each reasoning type. For instance, the primary scaffolding means for the theme of increased control differed, with suggestive Questioning predominating for cause-effect reasoning, while Instructing was more prevalent for means-end reasoning. A summary of the findings is presented in Table 3.

Table 1 For each enacted reasoning type, themes of strategies were constructed from similar intentions and means.

Reasoning type	Scaffolding intentions	Dominant scaffolding means	Constructed teacher strategy
Cause-effect reasoning	Scaffolding students' metacognitive activities	Questioning: Follow-up and counter questioning	Decreased control
	Scaffolding students' metacognitive-, cognitive activities or affect	Questioning: Suggestive questioning	Increased control
Means-end reasoning	Scaffolding students' metacognitive activities	Hints and Questioning	Decreased control
	Scaffolding of students' cognitive activities or affect	Instructing	Increased control

Cause-Effect Reasoning

When cause-effect reasoning was enacted, the teachers described their strategies in the sense of decreasing or increasing control. The teachers described that they wanted the students to think for themselves, but whether the teachers decreased or increased control were connected to certain content and teacher's preferred conclusions.

Decreased Control

When the teachers decreased control and cause-effect reasoning was enacted, the teachers had the intention to scaffold the students' metacognitive activities. Here, they manifested that they wanted the students to think for themselves, but also that they wanted the students to be able to express themselves. The teacher Oscar expresses his intention as:

> *I want to make them think for themselves. Why do they write what they write? […] They have to reflect, why do they write what they write? Is it because I have said so? Or is it because they have thought for themselves based on the questions?*

With this intention they foremost used the scaffolding means Questioning. This is also reflected in the teachers' descriptions, where they described that they use follow-up or counter-questions to let the students think, express their thinking, and reach conclusions. With this strategy the teachers pressed that they did not want to provide answers and that they refrain from directly Explaining.

How Oscar makes use of Questioning can be seen in Excerpt A, where a student asked whether it is good with many windows in a house. Oscar responds with a counter-question. The student answers the counter-question by expressing his belief of the effect of many windows. Oscar then acknowledges this through the means Explaining, but also widens the perspective by indicating other effects of windows through further Questioning.

Excerpt A

Student:	Oscar, I have a question for you. Is it really good to have many windows in a house?
Oscar:	Many windows?
Student:	Yes
Oscar:	Why would it be bad?
Student:	Doesn't it lower [intensity]? Well, you know, they take up space on the wall.
Oscar:	Well, the insulation effect is definitely worse. But what do you get with many windows? Light!
Student:	Light! And fresher air, that is, if you open them all.

Oscar describes that the intention was to not supply the student with the answer, but to make the student think for themself. Additionally, Oscar's intention was for the student to be able to express his thoughts. By the means of the counter-question, Oscar describes that:

> *I want to hear how they think. They have to be able to express their thoughts. Very important. They know why they make the decisions they make, based on whatever it is based on. Whether it's a technical task or whether it's a choice in life, for the rest of their lives. If they are not grounded in what they think and feel, then it is very difficult or those who are grounded will have a much easier time than those who are not.*

As Oscar's intention is focused on the student's verbal expression of reasoning, Oscar also makes use of the scaffolding means Explaining. Hence, when his student struggles to express the effect of windows, he confirms and through Explaining, give further support to the verbal expression of the student's reasoning by using the correct phrase "insulation effect".

Increased Control

The teachers also increased control when cause-effect reasoning was enacted. Here, the intention differed between scaffolding of metacognitive-, cognitive activities and affect. The teachers described that there are certain situations where the teachers themselves has an idea of right and wrong. In addition, they describe that drawing from experience there are certain content in the process that they do not want the students to struggle with. For example, Harry describes that the understanding of how the DC-motor works should not be an obstacle for the students. Thus, he gives the students more support in relation to such content:

> *… because some students think that if they put the motor in the wrong place, they can't change from rear-wheel drive to front-wheel drive, but it's really just a matter of changing the poles on the motor and sometimes it can be good for them to get some guidance on that. Because that should not be the hitch and it's always something they can test at the end …*

Like with decreased control, the teachers dominantly used the scaffolding means Questioning. However, there is a difference in the nature of the questions used. With this strategy, the questions they used were more of suggestive questions, guiding the students to a specific conclusion. The teachers described that they still want the students to think for themselves, hence the use of questions, but toward answers that the teachers preferred.

How the teacher Harry makes use of questions, increasing control, when cause-effect reasoning was enacted can be seen in Excerpt B. Harry askes a question for the student to reason about possible effects of the placement of the battery. The student then provides a conclusion, which was not what Harry had in mind. Thus, he follows up with suggestive questions about the weight of the battery. Followingly, the student draws the conclusion Harry is seeking.

Excerpt B

Harry:	… Why would you want to move the battery?
Student:	If it doesn't work to connect it.
Harry:	Mm, can you think of anything else? How much does that weigh?
Student:	I see, it will be too much weight on one side.

Means-End Reasoning

When means-end reasoning was enacted, the teachers also used strategies in the sense of decreased and increased control. The teachers described that they wanted the students to do themselves. Whether the teachers decreased or increased control were connected to the specific deemed need of the student.

Decreased Control

When means-end reasoning was enacted and the teachers decrease control, they had the intention of scaffolding students' metacognitive activities. Here, they described that they wanted the students to do on their own and test. Followingly, they described that they want to give the students freedom to draw their own conclusions and that this is connected to certain students that the teachers deemed could be given this freedom. The teacher Jack described this intention by pressing how he do not want to use Instructions:

> *I don't want them to follow my instructions. I want to give them some space and see how they think. I say: "You are the project manager, you decide!". I don't want to say "No, you can't do this, you can't do this. You should do this!". No, it's not good to set strict limits for students in technology education.*

With this intention, the teachers used Hints and Questioning when means-end reasoning was enacted, thus refrained from giving Instructions. In Excerpt C, the teacher Oscar makes use of Questions and means-end reasoning is enacted. The student wonders how tall the windows should be in the house he is drawing. Oscar then directs the student's attention to the windows in the classroom using a question, so that the student can relate to their size. The student can then draw the conclusion that his windows cannot be as tall as them and Oscar continues to relate to the windows in the classroom through Questioning. The student then draws the conclusion that the windows should be half the size of the ones in the classroom.

Excerpt C

Student:	So how big should it be?
Oscar:	Look. How big is a window here? [points to the windows]
Student:	I can't have windows like that.
Oscar:	No, but if you know it won't be like that, how small do you want it to be?
Student:	Half of that.

Increased Control

The teachers described that they sometimes needed to give more support to students to manage with their work in the process. Here, they increased control as a strategy when means-end reasoning was enacted. They did this with the intention to scaffold students' cognitive activities as well as affect and described that their decision to provide more support in their scaffolding was connected to the individual student's needs in the moment. In addition, they also described the importance of knowing their students and knowing what obstacles in the design project could be. With this intention they dominantly used the scaffolding means Instructing, as a strategy to increase control.

In the interaction in Excerpt D, the teacher Jack increases control and means-end reasoning was enacted. Jack has seen that a student has placed the DC-motor at a location that will prevent it from function properly. He draws the student's attention to this by the scaffolding means Questioning. When the student confirms, Jack gives a Hint about the DC-motor needing to be placed higher up from the cardboard. The student lifts the DC-motor up from the cardboard to check if that was what Jack meant. Jack then proceeds to give Instructions about means the student needs to use. He also asks a question to confirm that the student understands, and the student confirms. Jack then repeats the Instruction of means, and the student proceeds to ask what he can use to change the level of the DC-motor. Followingly, Jack gives clear Instructions of means, what the student can use, where it should be used and why.

Excerpt D

Jack	The DC motor, where is it? It's here?
Student:	Yes
Jack:	I feel that the DC motor has to be lifted up a bit. Or? Just, it's a bit close.
Student:	Like that?
Jack:	You can fix it, it's no problem. … Then, you can put something underneath from that side. For example, lolly sticks here. Otherwise, the DC motor will not work 100%. Do you understand what I mean?
Student:	Yes.
Jack:	You have to put something here on that part. So, lift it up a bit.
Student:	Okay, what can I put...?
Jack:	You can put some glue here, or cardboard. Only on this part, not on the whole. Do you understand what I mean?
Student:	Yes.
Jack:	Just here, on this part, and then glue. Because this is so small. So, lift it up in the front.
Student:	Yes.

Throughout the interaction, Jack uses Instructions with the intention to scaffold the student's cognitive activities. Hence, provides support for the parts of the task that he deems that the student is not currently capable of accomplishing independently. When Jack reflects upon this interaction, he expresses that his decision of how to scaffold is linked to the needs of the specific student:

> *He did not know, he has not tried yet when it connects to the microbit and works, but I know. So, I saw that, when it's supposed to spin, it will not spin, because it will get stuck in the cardboard. You see, it does not work if it is stuck like that. But [the student] has not seen it. He just puts things together. So, you have to be careful with small details with some students and give them feedback all the time.*

Similarly, in Excerpt E, Oscar notices that there is a student's drawing is inaccurate. He draws the student's attention to this by Questioning. Followingly, he Hints about the means of bringing the garage down to ground level. However, the student interrupts him by expressing frustration over the change. Oscar continues to Explain to point out what is inaccurate but realises that the student is frustrated so he continues with Hinting about another means. The suggested means, a ramp, would be easier for the student to implement, as she would not have to change the current design. The student still express frustration, and followingly Oscar gives clearer Instructions of what actions the student should take. Here, means-end reasoning is enacted and Oscar scaffolds with the intention to scaffold the student's affect, trough the means Instructing.

Excerpt E

Oscar:	Is that a garage?
Student:	Mm
Oscar:	Then I would put the garage on the same level as the ground. Otherwise...
Student:	You're making it very complicated for me now.
Oscar:	If you imagine that you have a garage here, and you have 30 cm. Should you have a ramp up to the garage? You can do that.
Student:	How complicated. I don't know how I did it. Oh, I must have my [sketches].
Oscar:	Start by drawing a line at the bottom and then draw your house, the actual height of the house.

When reflecting on the interaction in Excerpt E, Oscar describes that his point of departure when interacting with students is to have high expectations, but also to change the support if needed. When the student got frustrated and did not know how to move forward in the process, Oscar changed to Instructing:

> *That was my starting point, talking about having high expectations based on who it is and so on. But when she didn't [understand], well, then I have to go back. So that's a typical example of when I have to go back and explain and step in.*

Highlighting Differences in Strategies

For both reasoning types, the teachers used decreased or increased control as strategies. These strategies were, however, enacted in different ways depending on enacted reasoning type. When cause-effect reasoning was enacted, the teachers decreased control with the intention of letting the students think for themselves and they used Questions frequently. While, when means-end reasoning was enacted, the teachers wanted the students to do on their own, using both Hints and Questions regularly. Correspondingly, when cause-effect reasoning was enacted and teachers increased control, they often had the intention of scaffolding towards a preferred conclusion by dominantly using suggestive Questioning. In contrast to this, when means-end reasoning was enacted and the teachers increased control, they had the intention to give more support to students that needed help to manage in the process. They did this by frequently using Instructions, telling the students what to do.

Discussion

With the aim to describe teachers' support strategies in relation to enacted verbal reasoning in the design process, we constructed themes as strategies for each reasoning type with joint patterns of scaffolding intentions and means. The findings show that the teachers depending on enacted reasoning type, used different scaffolding means in connection to different intentions. This reflects previous research indicating teachers' dual roles as facilitators (Goldschmit et al., 2014; Kimbell & Stable, 2007) and instructors (cf. Lysne & Esjeholm, 2021; Svensson and Johansen, 2019) in the design process. Furthermore, the difference in the teachers' strategies of decreasing and increasing control highlight the teachers' balancing act of keeping the student motivated through moving forward in the design process, while still scaffolding for the student to be able to reach their own conclusions. Here, Instructions could be used, staying within the student's Zone of Proximal Development. For the strategies of increasing control when means-end reasoning was enacted, the knowing of students' needs was emphasized, a fundamental aspect of scaffolding (cf. Siu and Wong, 2016). Additionally, there was a notable distinction between scaffolding students' cognitive activities and affect. When scaffolding students' cognitive activities, the teacher's subject-matter didactics and experience is relevant. The teacher can decide on scaffolding based on experience. Whereas, when scaffolding student's affect, teaching and learning may need to be abandoned (Meyer and Turner, 2007). This frames the scaffolding of the teacher Oscar (Excerpt E), who in the last teacher turn adjusted his support, Instructing towards an action within the student's Zone of Proximal Development, and diverting from the cause of the student's frustration.

The prevailing means of scaffolding differing in connection to the enacted reasoning type suggests, as emphasized by Sheoratan et al. (2024, p. 163), that "teachers scaffold *doing* and *thinking* differently". However, we are cautious about implying this due to the intrinsic relationship between the two reasoning types of focus. Since cause-effect reasoning supports means-end reasoning (Hultmark et al., 2024), enactment of cause-effect reasoning may implicitly support means-end reasoning. This intrinsic relationship was evident in the data, as some interactions contained both reasoning types. This was beyond the scope of this study, but we urge for future research to explore scaffolding in connection to the relationship between the two reasoning types.

Furthermore, in the contexts of the study, learning revolves around learning to and about the design. In other contexts, such as integrated STEM projects (e.g., Sheoratan et al. (2024); Siverling et al., 2021), learning through the design process is also pertinent. At the same time, the nature of the relevant reasoning types differs for technology and science (e.g., Hultmark et al., 2024). The focus on both means-end reasoning and cause-effect reasoning, as in this study, captures and highlights aspects that are relevant to teaching and learning in technology education.

One focus within this study was the enacted reasoning between the teacher and student in the design process. Meaning that the focus was not solemnly the students' reasoning, but rather the joint reasoning among teacher and student. Other studies have focused more on the expression of the students' reasoning (e.g. Siverling et al., 2021). The focus in this study prevents us from drawing conclusions about how the teacher supported the students' reasoning. However, this study contributes to the knowledge about the relations between teacher support and reasoning in the design process. Yet, further research into the connection between teacher support and students' reasoning is needed.

In summary, we conclude that teacher-student interactions in the design process in the technology education classroom carries substantial meaning and value. This has implications for both teaching and learning in technology education. Through the interaction, the teacher can decide on scaffolding in relation to the student's learning and reasoning (cf. Fahrman et al., 2019). In this elusive process, framing the reasoning is important in shedding light on the teahers' professional knowledge.

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