International Journal of Technology and Design Education
https://doi.org/10.1007/s10798-023-09849-3

Exploring the nature and role of student-to-student talk and questioning among young children in technology and design education

Wendy Fox-Turnbull[1]

Accepted: 18 August 2023

Abstract
Classroom conversation between students is complex and used for multiple reasons every day. Student dialogue also allows teachers insight into student's learning. This article presents findings from a qualitative study that used dialogism, a branch of sociocultural theory, to investigate in depth student to student (inter-student) questioning learning in technology in junior primary classrooms in small town in rural South Island, New Zealand. Inter-student dialogue was investigated while students from Year 0–4 undertook a technology unit to design and make props and costumes for their class item in the up-coming school production.
In this study insight was gained into aspects of development of student understanding in and of technology through the recording and analysis of inter-student talk, observation, analysis of work samples and focus group interviews with the students and their teachers. It also allowed insight into students' views of the value of talking with their peers. This study aimed to contribute specifically to the fields of classroom dialogue, student learning, formative assessment and technology education. Three key findings are reported, the first related to teachers' views of classroom talk. Both were aware of the value of talk in the classroom but struggled to implement in-depth student dialogue for a range of reasons. The second finding focused on students' views on talk. Initially students recognised that they used questions to ask their teacher, peers, or parents for help, however after the study the data showed that a more sophisticated understanding of dialogue emerged. The third key findings focused on the nature of students' questions while undertaking technology practice. Findings showed that social interaction played a key role in developing participants' understanding of technology and that they used questioning to clarify, collaborate, support and defend themselves.

Keywords Technology education · Pedagogy · Dialogism · Inter-student questioning

✉ Wendy Fox-Turnbull
wendy.fox@waikato.ac.nz

[1] University of Waikato, Hamilton, New Zealand

Introduction

The aim of the research is to understand the impacts of student-to-student conversation on learning in technology and design education and is underpinned by dialogism a subset of sociocultural learning theory (Skidmore, 2020). Technology and design education, a mandatory subject in New Zealand curriculum was introduced after debate, research and dialogue about the future of New Zealand. The New Zealand Curriculum (Ministry of Education, 2007, 2017) outlines effective pedagogy. The curriculum encourages teachers to consider the social and cultural contexts of the student and create a supportive learning community. It encourages student and teacher reflection to enhance and facilitate shared learning. Learning should make connections to prior learning and provide sufficient opportunities for investigation and exploration. Thus, this research was aligned with these values from the New Zealand Curriculum (Ministry of Education, 2007, 2017).

This research was initially intended to provide insight into primary school teachers and students' use of facilitated intercognitive talk to improve learning in technology and design with a specific focus on student-to-student questioning. It aimed to investigate student-to-student questioning with the eventual aim of introducing a talk-based tool, Technology and Design Observation and Conversation Framework (TOCF) (Appendix1), a tool which assists teachers to observe and encourage students to talk to and question their peers about their learning in technology and design by facilitating intercognitive talk (Fox-Turnbull, 2016; Swathi et al., 2020).

An initial concern of the researcher was that teachers could be overly dependent on the framework and that this would impact the students' questioning. This was mitigated by the researcher's presence in the teaching and learning space as she was a trained primary school teacher and teacher educator in technology and design education. However, this concern was unfounded because it became evident very early on that for the framework to be effective the researcher needed to understand the current role and practice of student-to-student talk and questioning within the participatory classrooms. Thus, this became to focus of this research, which aimed to answer the question *What is the role of student questioning and what are students and their teachers' perceptions of the role of student questioning in learning technology education*? was to explore the role of talk played in the participatory classrooms and the views of teachers and students on the role talk and questioning played in learning technology and design. This article, therefore, presents and discusses the findings of an investigation into the nature and role of student-to-student talk and questioning in technology and design in junior primary school.

The role of talk and questioning in learning

Bakhtin (1981) stated that learning does not come from within a person but between people collectively searching for the truth. This process he called dialogic interaction. The theory of Dialogism is based on the premise that we learn through talking with others (Wegerif, 2020). Skidmore (2020) suggests that Yakubinsky emphasised the naturalness of dialogue as opposed to monologue, which implies power and authority, whereas interruptibility is a key characteristic of dialogue.

Several researchers have investigated the implications of dialogue in the classroom (Alexander, 2008; Mercer & Littleton, 2007; Wegerif & Major, 2019). Wegerif and Major

(2019) particularly reconnect us to Buber's idea of the 'space in-between. Through dialogism in education, learning occurs through dialogue, which can be considered as a shared space between the participants, a space where new understandings can develop, and new learning occur. (Yakubinsky & Eskin, 1997) also assists in the understanding of the nature of dialogism in group work in educational settings. For teachers to facilitate deep and meaningful dialogic activity they must give up their power (Skidmore, 2020). Yakubinsky and Eskin suggest a clear link between the type of talk in the classroom and the position of power. When a teacher instigates a teaching sequence that involves obtaining pre-determined answers to a set of questions the talk may appear dialogic but, it is a monologic dialogue with the teacher in the position of power.

Oral communication has an important functional place in the primary classroom but is not often the subject of explicit teaching and learning (Gagnon, De Pietro, & Fisher, 2017, cited in Colognesi et al., 2020). Classroom interaction is very complex and used for multiple reasons every day. Students use talk to collaborate, support, and defend themselves and others to question and query and solve disputes (Warrick & Cook, 2020). Collaborative group work is underpinned by sociocultural theories suggesting that knowledge is constructed and acquired through interaction among peers in goal-oriented tasks (Lantolf, 2010). Dialogic practice is considered an important means of achieving and promoting critical thinking (Liang & Fung, 2020; Sedova et al., 2019). Questioning is a favourite pedagogical strategy undertaken by teachers (Shanmugavelu et al., 2020; Wangru, 2016). Buchanan Hill (2016) defines questions as sentences that are interrogative in form and function with instructional cues that convey instructions, directions or elements to be learned. Early examples of questioning to facilitate critical thinking are attributed to the Greek philosopher Socrates. Since then, questioning to facilitate critical thinking has been an important part of the teaching and learning process. However, Nappi (2017) states 60–80% of questions asked by teachers require students to recall information. Questioning skills need to be developed to facilitate a greater percentage of higher-order question, more effective for student learning.

The connection between questioning and academic progress is well known. Several taxonomies and models have been developed to provide a structure and focus for questioning to promote learning (Bloom, 1956; Christenbury & Kelly, 1983; Elder & Paul, 2007; Webb, 1997). A more recent focus for investigation in this field is into patterns of interactions between teachers and students, including an investigation into how effective use of questioning techniques increases the probability of achieving instructional goals (Buchanan Hill, 2016; Shanmugavelu et al., 2020; Wangru, 2016). Wangru (2016) identified that the type of question impacted the quality of interaction between students. Referential questions, those where the teacher has no preconceived notion of the answer, tend to create more interaction in the classroom than information questions do. They also suggest that the quality of the conversation also improved with the use of referential questions because they invoke critical thinking. Engage in explicit reasoning by using 'because' to explain the reasons for their opinions, asking 'why' in their dialogic interactions to seek justifications from their peers, using 'if' to make transparent their assumptions and reasons, and using 'but' to introduce reasoning or provide a link to it are a number of strategies to assist classroom student to student dialogue (Liang & Fung, 2020).

Claxton et al. (2013) discuss in depth the language of building learning power, putting students at the centre through developing key behaviours: resilience, resourcefulness, reflectiveness, and reciprocity. A critical aspect in the development of these behaviours is students' ability to ask questions of themselves and their peers. Metacognition (thinking about one's thinking) and metatalk are key components of these processes. Metatalk brings

attention to talk about dialogue, however, talk about talk has not been widely developed as a pedagogical tool to improve student learning and develop critical thinking. (Edwards-Groves & Davidson, 2020). In their study, Edwards-Groves and Davidson (2020) investigated how explicit talk about dialogue shifted teachers and young learners' participation in dynamic talk; finding that it established a strong foundation for building shared responsibility for contributing to and managing learning.

Recent studies have identified that questioning is useful across several primary learning areas. Eason et al. (2021) identified scripted questions led to parents asking their own additional questions focused on their children's maths comprehension or engagement and the fewer scripted questions the fewer the non-scripted questions. In the arts, specifically in drama when students discussed an oral performance in small groups, their feedback included more suggestions than when it was written, thus oral peer feedback has the strength to be more convincing than written feedback (Colognesi et al., 2020; Sedova et al., 2019). Young children frequently accompany drawing activities with descriptive, reflective, and social conversation, verbally monitoring, supplementing, and sharing the progress of their drawings (Thompson, 1990). When learning literacy when children were responding to 'how' and 'why' questions their talk was more cognitively challenging (Paatsch et al., 2019). Juuti et al. (2020) found that in science ideas are argumentative by nature and talk can be dialogic if the teachers and students use scientific ideas to talk about natural phenomena and evaluate competing ideas, however, although dialogic teaching is beneficial for learning, it is seldom used in science classrooms (Larrain et al., 2018).

Student dialogue in technology and design education has been found to give insight into students' learning by teachers (Fox-Turnbull, 2017, 2018). Doyle et al. (2019) recognised the value of engaging students in higher levels of thinking in technology and design including novel approaches to questioning. However, in her study, Swathi et al. (2020) suggested that teachers need to spend time familiarising themselves with potential questions. This study worked on the assumption that the same would apply to young students. It aimed to give further insight into questioning dialogue between students while learning in technology and design. It also enabled some insight into students' perceptions of how talking to their peers assisted their learning.

Methodology

The study was a qualitative study aimed at developing a deep description of student-to-student talk and questioning during a technology and design unit, drawing on Dialogism, a branch of socio-cultural theory, born from the works of Vygotsky (Fernandez-Cardenas & Reyes-Angona, 2020).

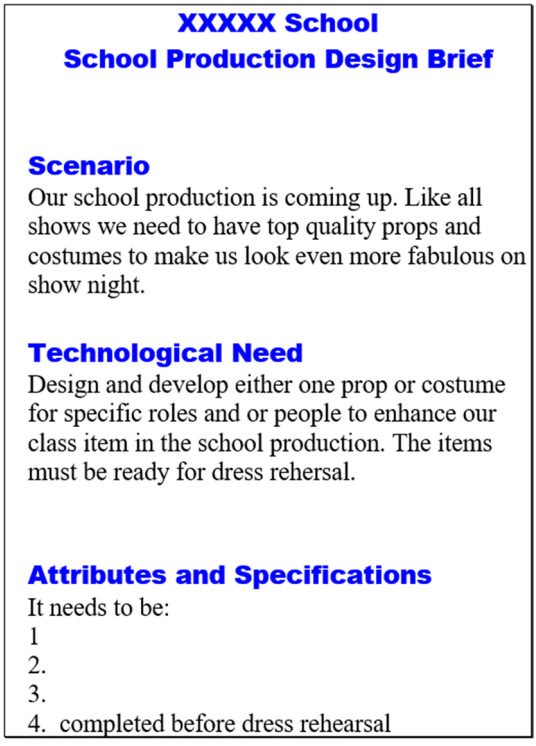
This study involved extensive participation by the researcher, classroom teachers and students in the study. It was carried out in a small rural school in the South Island of New Zealand. Most students came from a range of rural contexts and support industries. In New Zealand, most rural children spend considerable time out-of-doors and are familiar with tinkering and making things. Convenience sampling was used for selecting the school and teachers. Three teachers of children in Years 0–4 (5–9 years of age) were initially recruited, however, student and teacher interviews only occurred in two of the three classrooms as the third teacher was unable to participate at the last minute. Students participated in a technology and design unit centred around props and costumes for their class items in the upcoming school production. The Year 1–2 item was based

on the book 'Wake-Up Bear' by Lynley Dodd and in Year 3–4 Synchronised Swimming. The unit was planned to meet the requirements of technology education as envisaged in The New Zealand Curriculum (Ministry of Education, 2007, 2017). The initial brief for the unit is shown in Fig. 1.

Data included a focus group interview with two participant teachers-TS and TD, focus group interviews before and after the unit with students from two of the classes (Class H, years 1–2 and Class M, years 3–4), researcher observation, planning documents, student and teacher generated artefacts, final student technological outcomes. In both classes, students worked in small groups of four to five. Group audio recordings were undertaken while students were working in groups.

All participants were voluntary and consented to be part of the research. They were informed of their right to withdraw from the study anytime, via the initial information letter. Only children whose parents consented were included in the research, although all children participated in the planned technology and design learning. The school was accessed through the principal and Board of Trustees chair. Participants were aware that anonymity was not able to be guaranteed because of the school uniform worn by participants in photographs taken as data however every action was taken to safeguard participants. All participants are referred to using pseudonyms.

Inductive thematic coding was used to analyse the findings. All audio recordings were transcribed and coded and recoded in an Excel spreadsheet. The researcher was the only coder, thus inter-coder reliability was not applicable. Relevant photographs were also loaded into the same spreadsheet for analysis.


XXXXX School

School Production Design Brief

Scenario

Our school production is coming up. Like all shows we need to have top quality props and costumes to make us look even more fabulous on show night.

Technological Need

Design and develop either one prop or costume for specific roles and or people to enhance our class item in the school production. The items must be ready for dress rehersal.

Attributes and Specifications

It needs to be:

1

2.

3.

4. completed before dress rehearsal

Fig. 1 The initial design brief

Results

The study investigated the role talk played in participant classrooms and the views of teachers and students on the role talk and questioning played in learning technology. Results are reported in line with three key findings: teachers' views of classroom talk, students' views on talk and the nature of students' questions while undertaking technology practice.

Teachers' views of classroom talk

The two participating teachers were interviewed five days into the study. TS, a male teacher with three years of teaching experience, described himself as having 'average experience' teaching technology and design. He stated "Technology -I've done a few things and have a couple of times. I've worked through the process, the proper process of designing and all that sort of things". TD was in her fifth year of teaching at the time of the interview. She had undertaken some technology and design professional development when first at the participatory school but admitted that she still found the distinction between technology and design education and technology tools confusing.

> I still get confused between, and it's the same with the kids, they have such a focus it being electronics rather than literally anything. So even as myself as a teacher having to separate myself from thinking technology is just electronics like it's not just electronics.

Both teachers were aware of the value of talk in the classroom. TD referred her former Year 13 art teacher to assist her in the articulation of her view on the value of talk.

> In Year 13 I had a wonderful art teacher, and he said he hates museums and art galleries because people think they can't talk. And he said, "I mean people need to share their ideas about what they are seeing. When you can't talk to people in these spaces are made to be quiet and harsh". And he said that is "so wrong". And I feel like it as the same in the [class]room.

However, both teacher participants struggled to implement in-depth student dialogue for a range of reasons. TS admitted that sometimes that giving his students the freedom to talk was challenging. He was happy for students in his classroom to talk within boundaries, "I generally don't mind as long as it doesn't get out of control" but then went on to say "Sometimes…I know I'm guilty of this myself, is that sometimes I take over. And I actually just don't sit there and let the kids talk". TD indicated that talk had a place in her classroom but within boundaries.

> As long as the kids are being respectful about it. As they have ideas coming out that means they are wanting to share it. So, I don't know, as long I think the kids have a mutual understanding that if I'm talking, they shouldn't but then they always have a chance to share.

However, she also found classroom noise could become a distraction, "I still like manners in my classroom, I am someone who is quite sensitive to noise. I don't like a lot of noise". She also believed that classroom talk was also dependent on the age, attitudes, and skills of individual children "I think it just depends on the age of the kids, but I think it also just depends on the kid".

Students' views on talk

Questions in the focus group interviews explored students' understanding of the role talk and questions played in their learning. In Class H when initially asked whether talking to other people would assist their learning in technology and design all but one answered negatively. The exception, Ingrid, recognised that talking to her teacher might help her. She stated, "Yes…Yes your teacher…. because she helps you learn…… because if you don't know something you can just go up to her and ask her and then you can learn that word". At this point, Hannah changed her response from 'no' to 'yes', recognising that she learned when her peers called out answers to questions previously unknown as demonstrated in the sequence below.

> Hannah: Yes, when someone's calling out.
> Researcher: Tell me about that Hannah.
> Hannah: They tell you what they think, and you tell them what you think and then they are joined up [gestures with her hands coming together].

When asked who might help them with their technology Class H stated that their teachers or parents might help them. Students in Class M understood the assistance potential from a wider range of people, including neighbours, engineers and professionals, as illustrated in the following quote, "You're talking to people [and]going to learn to make this car, you think I might be best to talk to an engineer"; and tools, "there's a game that helps you learn. The game is Duolingo. It's like talking to people who use different words then you like, you could be like other people".

Students in Class M were also aware of the benefits of talking to people who are able to help them. Hope recognised their teacher's questions facilitated deeper thinking. She stated.

> because she [teacher] asked a question and you have to try and work them out in your brain. What goes on in there when you're not saying it out loud, but you are thinking so if she asks you a question you have to think about what you know and what you don't know. You might have to go away and find out about it and you're learning more words as you go on but you also understand what you're reading because you know what that words mean.

Fig. 2 Group Role Cards

The post-focus group interviews evidenced quite a change in understanding of the role of talk and questions in learning. In Class H there was evidence that the students understood that questions from peers assisted their thinking. Jen said "You try hard think about the question it makes you think about it, doesn't it? Something that you might not of thought of before but the question helps to make you think you do" She went on to say, "so we were able to think and talk about what might work and what might not work together" suggesting that dialogue with her peers helped clarify her thinking. Zana supported Jen's views but suggested what might happen with a lack of dialogue, "No cause then you wouldn't have their ideas and don't know what are your neighbour's ideas and then it would be like an old piece of rubbish". Cam summed this new insight very succinctly, "It makes your brain go because you are talking and helps me think".

Class M demonstrated further sophistication in their understanding of the importance of dialogue during their technology and design practice. Adam said, "They can explain like step-by-step instructions" and Hemi said, "You can talk to each other like where to put things". Jane stated "Okay so do not do it or do it. Is there something else that you could do when two people disagree? You can discuss the differences like a different thing" thus emphasising her understanding of the importance of compromise in collaborative technology and design practice. Hannah indicated an increased understanding of the value of dialogue in collaborative technology and design practice as evidenced below.

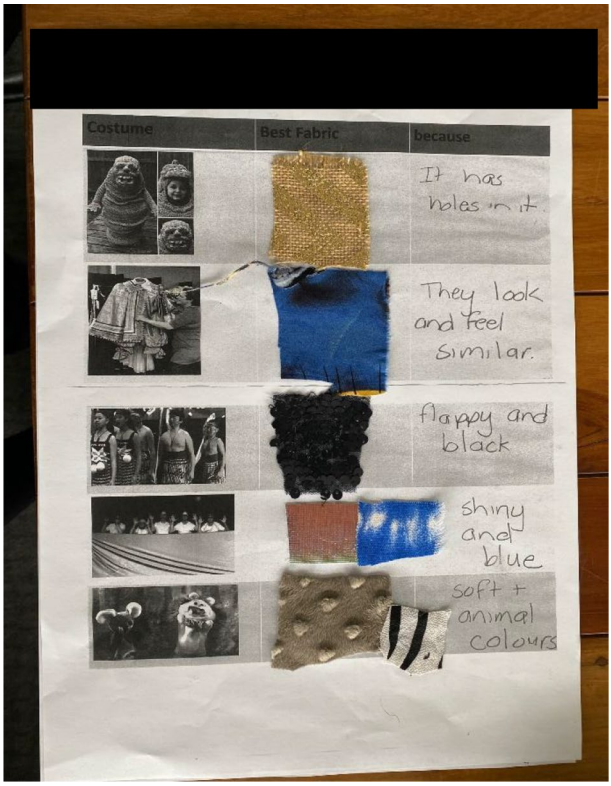


Fig. 3 match the best fabric to the costume activity worksheet

Like it okay so, they can give you their opinion if you like it or not. Like what colour? Helps you and gives you their ideas so you can put your ideas and their ideas together to make up something will it be good.

Students' questions while undertaking technology practice

After the initial focus group interviews and near the beginning of the unit the researcher introduced to students to the importance of talking to each other to assist their own and others' learning. Group roles for the students were established by identifying and explaining four set roles, aimed to assist learning and inclusion. In the first lesson, students were given a role card indicating their role for that lesson as seen in Fig. 2. It was envisaged that students' roles would change each lesson.

Initially the 'questioners' were asked to focus on asking of one question from the TOCF: Why do you think this? This was the only question used by the TOCF. Aimed to facilitate students talking about their reasoning for their answers to each other. However, analysed data showed that the questioners did not fulfil their role, with no evidence of them asking of the specified question. However close analysis of questions asked by the students to their peers identified three subthemes of questions asked by peers in their group work: Reassurance and Clarity, Extended Learning and Consensus and Peer Approval.

(i) Reassurance and clarity

The first subtheme was characterised by the students checking with each other to ensure they knew what to do or that they were doing the correct thing or reassuring each other that they were on the right track or doing well. Examples of questions asked in this subtheme include:

"What are you doing?" (Unidentified boy, Class H); "What do you think we should do?" (Hope, Class H), "Do you want it small or big?" (Ingrid, Class H); "That's good [points to an oval drawn by a girl]. Now we start colouring in?" (Ingrid, Class H) and "Do you like our lion? ROAR!" (Edgar, Class H).

(ii) Extended learning

The second sub-theme was characteristics by questions that assisted students in their learning within the given context. Had questioners used the questions asked of them, this is the sub-theme where they would have been situated. Examples of questions asked in this subtheme included: "Can you like knit a costume?" (Angus, Class M); "But you should need ahead if you are going to have masks?' (Unidentified boy, Class H); "Oh! Would it [a material] be good for Pyjamas?" (Bryan, Class M); "We need to draw the clothes, do we need to do the top?" (Edgar Class H); "What shall we do now? We are not searching out pools. Oh my God. Shall we search for 'sea animals' to design? Ok, I'll write s e a a n i m a l s- sea animals, or sea horse?" (Adam, Class M); "Why did you think that cream one was bad?" (Lily, Class M). This comment refers to an activity where students were asked to match the fabric to a costume as seen in Fig. 3.

(iii) Consensus and peer approval

The third subtheme was characterised questions asked to ensure that the whole group agreed with the decisions made by individuals and to gain the approval of peers within the group. Examples of questions asked in this subtheme included: "Shall we do a circle?" (Unidentified boy, Class H); "What colour do I need, yellow?" (Hope, Class H); "Ah, is that too much whiskers? Ah! It is like a cat" (Edgar, Class H).

Students' views on technology

In the pre-unit focus-group interview the students in Class H thought that technology was about tools, as exemplified by this quote "Technology is what you need to like make stuff" or about making things. Cam stated, "You might stick or glue some things together" and Ant suggested it was "to learn stuff So when we get older, we can make things like go-karts and planes. They help us go around the world". The students in Class M also understood that technology was but tools, with the prevailing view that it is electronic in nature. One child stated, "Things you can playthings on" and another said, "Like clocks like things have power". However, there was some understanding of technology practice emerging as exemplified in the following quote "can't build a house without knowing how to do it. You need a plan".

The post unit focus-group interviews took place on after the final day of teaching, when most groups of students had designed and developed their outcomes to mock-up stage. Some Class H participants continued to be quite specific, identifying that technology was the artefacts they had designed and made. Zana said, "You have like props and have like shows and stuff…we're going to use them". Hope recognised a difference between a previous unit, which involved the students planning a go-cart, "because last time we looked at carts, now we are making stuff". However, others had a broader view of technology after undertaking the unit as best evidenced by Edgar, who understood that some technology is about a modification to meet a need, "It's when you make something, then you draw something and then try to make something…… it is the thing that we need to change and it could be about making a prop for something". And Ron recognised that technological practice is not always successful and understood the value of failure. He stated.

> because sometimes gonna try and try and try like the guy who did the first light bulb…. because he took lots of tries [to] make it go. He did 10000 ways, because sometimes they can be wrong and sometimes they can be right.

In Class M also expanded their view, although not quite letting go of the idea that technology uses power. This is most clearly evidenced by Hannah who said,

> Everything that's got power is technology and some things that don't have power are technology. Like the stuff in shows. Like for our swimming things you would use the tarpaulin to make it look like a swimming pool. And the swimming caps make it look like we are swimming.

Her reference to swimming came from the context of their class item- a synchronised swimming skit. Her group designed the 'sea scene' on the front of a tarpaulin representing the water pool. Lily also understood a wider view of technology after the unit. She said "Pretty much anything is technology, like buildings and things" She also recognised technology beyond her classroom experience "We wouldn't have kitchens stuff in the household so we couldn't cook stuff".

These results indicate that students developed a deeper understanding of technology and design and technology practice during the unit. It also suggests that although the TOCF implementation did not go according to plan, students did gain a deeper understanding of the role of talk and questions played in learning technology and design.

Discussion

Dialogue undertaken by the participants in this study was set within an identified authentic context- the technology and design unit and was characterised by interruptibility as suggested by Skidmore (2020). During the unit students advanced and explained their understanding of technology and design. The activities the students undertook during the unit were heavily dependent on questioning as they worked collaboratively on group designs. This suggests social interaction played a key role in developing their understanding of technology. These findings further support previous research by Fox-Turnbull (2016) and Fox-Turnbull and Swathi (2020). In this study students used questions for a range of reasons, one focused on 'extended learning'; the other two are more managerial in nature. These findings support Warrick and Cook's (2020) suggestion that questioning is a powerful pedagogical strategy. However, this infers questioning as a teacher's tool. These findings suggest questioning as a tool for students can assist in learning. Student participants in this study used questioning to collaborate, support and defend themselves as evident in the subthemes 'reassurance and clarity' and 'consensus and peer approval'. Liang and Fung (2020); Wangru (2016) both identify the potential of questioning for students. This study also highlights the need for purposeful teaching of questioning with careful scaffolds in place to develop questioning skills in students to maximise the potential impact of student-to-student questioning.

The participating teachers mainly referred to teacher-directed talk when asked about talking in the classroom and did not indicate their understanding of and views on the role facilitated group dialogue played in learning. This is not surprising as neither mentioned the cognitive benefits of structured dialogue and high-level questioning in their classroom. The majority of questions asked by teachers required recall of information. Nappi (2017), Claxton et al. (2013) and Clarke (2008) and Mercer and Littleton (2007) suggest that this is not uncommon, but can be that it can be rectified. It is also interesting to note that both teachers indicated that they required respect and were hesitant about lack of control and increased noise when students worked collaboratively in groups and aligned with Yakubinsky and Eskin's (1997) view of questioning and power relationships.

Despite these reservations, the participating teachers allowed dialogic conversation, with questioning to occur during the study with results showing that students in both classes made gains in their understanding of technology and design. During their post-unit focus group interviews students reflected on the role talk and questioning played in their learning (metatalk). Students in both classes recognised that they used questions to ask their teacher, peers, or parents for help. Again, not surprizing given their age. In addition, the data shows that a more sophisticated understanding of dialogue emerged. Hannah and Jane's comments about the merging of ideas between people support Wegerif and Major's (2019) connection with Buber's concept of the 'in-between space', by intimating that their conversations allowed them to arrive at understandings that neither conversation participant had previously. This further supports Edwards-Groves and Davidson's (2020) findings that talk talk facilitated some

students' understanding of the power of talk to achieve new learning. The findings also suggest the potential of developing skills in students to ask higher level questions and require of each other, deeper thinking to assist their own and others' learning. Several models assist with this (Bloom, 1956; Elder & Paul, 2007). The question from TOCF initially introduced to the students was a higher-level question and required students to reflect on and justify their thinking. It was also based on 'reflection', one of the five desirable behaviours for learning identified by Claxton et al. (2013) and used by Fox-Turnbull (2018) in the TOCF because of its relevance and importance to technology and design practice.

Conclusion

The study highlights the potential for student-to-student questioning to advance learning in technology and design through the sharing of ideas and facilitating collaborative thinking. Asking questions to peers also assisted students with a sense of belonging, as they clarified ideas and checked in with peers, as they sought assurance and clarity. When teachers model the asking of higher-level questioning and assist students to do the same, they develop opportunities to increase the depth of learning for their students in technology and design.

Although findings do not advance understandings about the use of the TOCF (Fox-Turnbull, 2018) for facilitating dialogue in technology and design they do suggest that the students understand that talking to peers can assist their learning in a number of ways. This would suggest a readiness to further develop a questioning culture within primary technology classrooms. Swathi et al. (2020) suggested that teachers need to become very familiar with the questions from the framework before implementing its use in the classroom. This study shows that the same is true for and possibly even more important for students. They should be prepared for and taught the reasoning and relevance of questioning and the protocols of asking predetermined questions as a tool for learning.

For the TOCF framework to be truly tested as a tool to assist student-to-student dialogue in technology and design a longer study is recommended. In future participatory classrooms, considerable time needs to be taken in establishing a classroom climate within which the asking of deeper questions to enhance dialogue is modelled by teachers. Also, where students engage in carefully scaffolded metatalk, and ask deep-level questions of their peers as a part of their normal classroom practice, thus outlining potential future research.

There were several limitations in this study. The first was that the data gathering period was too short, in part decreased by the sickness of the researcher and high levels of student absence. The study occurred at the tail end of the COVID-19 pandemic when New Zealand still had isolation requirements for all people feeling unwell or identified as close contacts. Another limitation related to the researcher's role. She was the main teacher in the unit, preparing and planning all the activities. Although this worked well for the students, had the researcher been only focussed on data gathering additional useful data may have been gathered.

Appendix 1:

Technology Observation and Conversation Framework (NZC: Primary) Children Year 0-3

Nature of Technology				
Resilience: CT	Transference: CT	Flexibility & Sophistication: CT	Reflection: CT	Socialisation: CT
Ask: How can you get better at using this? Who might help you with this? What might be a better thing to do this job? Who might help you make this? **Notice:** students repeatedly having a go at using technology	**Ask:** Where else might you use this thing for? Have you done anything like this at home or with your family? Where have you seen this before? Have you used this before? What might this look like in 20 years' time? What did you notice about the way that works? What questions would you like to ask the people who made this? **Notice:** recognition of technologies new to the classroom setting	**Ask:** Who might benefit from this *technology**? Why? How else might this be used? Why is this a good *thing*? What would you like to ask the person who made this to find out about how and why it works? Which do you think is the better/ best (comparing a range of similar items)? Why? **Notice:** new and increasingly sophisticated explanations as to what technologies are and how they work	**Ask:** Tell me why this is *technology*? Who might make this *technological outcome* best*?* Why? How might this be improved? Would this make a good *technology*? What works well? What does not work well? What do you think about when you use this technology? Is that (point to something) technology and why? **Notice:** the giving of an example of something that is or is not made by people	**Ask:** Who makes stuff (technology)? Why? Do you think people worked together to design and make this? How do you know? How do people work together to make this *technology*? **Notice:** the giving of an example of something that is made by people for people

*NB Where the words are italicised they may be replaced with the specific context the children are.

Resilience: CoT	Transference: CoT	Flexibility & sophistication: CoT	Reflection: CoT	Socialisation:CoT
Ask: How can you get better at using this *technology*? **Notice:** students repeatedly having a go at using a technology	**Ask:** How could you improve this for another group of people (state actual group such as adults, little brothers and sisters, grandparents)? Why was this *technology* made? Who else might want to make this? What changes would they make to make it better? Why? Have you seen this feature in something else? **Notice:** articulation of where, when and why students have seen or experienced a specific technology	**Ask:** Talk about how this *technology* works? Why does this *technology* work so well? Who might this *technology* not work for? Why? Who might it work better for? What makes this *technology* safe to use? What is a technology*?* *Why do we have this technology?* **Notice:** new and increasingly sophisticated description of successful design	**Ask:** What makes this *technology* a good one? How could you improve it? Why do you think this? How could this *technology* be made safer to use? Would your parents (Mum, Dad) use this *technology?* Would your parents (Mum, Dad) like this *technology?* Do you have the same or different ideas about this *technology* than your parents? Why? **Notice:** the giving of an example of a specific technology is or is not made by people	**Ask:** How might this *technology* have been better if more people helped make it? What do you think Mum or Dad {or another important person in their lives) would think of this? Why do you say that? What bits or parts in this *technology* help keep us safe? How do you know this was made by people? **Notice:** the giving of an example of a specific technology made by people for people

Technological Practice				
Resilience: BD	Transference: BD	Flexibility & Sophistication: BD	Reflection: BD	Socialisation: BD
Ask: How many ideas do you think you need? What would you change if the first idea does not work? **Notice:** students adding attributes and specifications to their brief as they come to light	**Ask:** What have you seen that is a similar to this? What have you learned through our research about this *technology*? What attributes did you add after our recent activity? **Notice:** attributes are enacted as specifications	**Ask:** Which is your best design idea and which is your worst? Tell me why they are in this order? What do you think might be the best solution to this problem? Why? **Notice:** modification to attributes and specifications if needed	**Ask:** Which design idea might the best? Why do you think this? What might be a better idea? What can we make to solve this problem? **Notice:** recognition of what circumstances led to a particular technological need Recognition of a range of possible solutions Know some solutions are better than others Justification of why solution are more likely to be successful recognising opportunities for developing technologies	**Ask:** How can working together help you decide the best solution to the problem? Who might help you think about doing this better? How might you help others to recognise an opportunity or identify the need? **Notice:** the understanding that conversation and working cooperatively can assist the process of problem/ solution identification Understanding that working together can mean doing different tasks on the same project Imitating adults in the articulation of a technological problem and /or solution Listening to others for ideas

Resilience: PP	Transference: PP	Flexibility & Sophistication: PP	Reflection: PP	Socialisation: PP
Ask: Why did you select this material when *X* material might have been more successful or better? Why did you select this component when *X* component might have been more successful or better? Was there another order for completing your tasks that might have improved your *technology*? Was there another order for completing your tasks that might have helped you succeed in the designing and making of your *technology*? **Notice:** Perseverance when finding the best materials to use in their designed technology, rather than using the materials that are easiest to use or obtain	**Ask:** What task is missing in this list? What tasks did you do in this technology practice that you did (or did not) do last time we did technology? What are the main tasks for a technologist (a person who designs stuff)? **Notice:** identification of stages/tasks from previous technology units and apply to new practice	**Ask:** Here are the tasks we need to do, what order do you think we should do them in? What comes next? Why did you do this? How did it help you? What will you do next? What resources will you need? **Notice:** talk about what stages/tasks they need to do Understanding of the order of stages/tasks to be completed: Sequencing of tasks Understanding of the resources (materials, components) needed and the order they are needed	**Ask:** How did having a list of tasks help you? What will you do next? What resources will you need? If you were doing this again would you change the order of the things you did? If you were doing this again would you use any other materials or tools? **Notice:** talk about what they are designing and why Ability to identify what resources they need	**Ask:** How did you share your tasks amongst people in your group? How did this sharing help you design and make the *technology*? When deciding what materials to us how did it help you being a member of a team? **Notice:** working collaboratively with others as a team identify tasks to be undertaken as a team identify resources needed (and when) sharing out tasks within their group

Resilience: ODE	Transference: ODE	Flexibility & sophistication: ODE	Reflection: ODE	Socialisation: ODE
Ask: If your first idea does not work what will you do? What other detail can you put in your *drawing/ model*? How might you improve the quality of your *technology outcome*? **Say:** Try again to do this, but in a safer way. Like this (demonstrate skill) Have another go Failing in technology is very useful because it is how we learn Have another go. You are just not there yet How might we make our design better? **Notice:** ability to continue working on a *technology drawing/ model/ outcome* to improve quality Total absorption while others are playing / working around them Not letting others distract them Repeatedly giving things a go after initially failing	**Ask:** What have you/we already learned that might help you with your *drawing/ model/ outcome?* Why/ How will this be useful? How did you determine the attributes? Who taught you to do that? How did you know that? Can you use (a feature) from something else? How can we do this safely? How have you used in your planning what we learned about? How can we do this safely? **Notice:** skills learned in skills-based lessons such as drawing, gluing, etc. used when making the actual *drawing/ model/ outcome* Transferring identified attributes from *design* to the *technology outcomes* Use of safe practices Use of research/investigation findings evident in planning/ drawing	**Ask:** Improve your design so that another person could make your *technology outcome* Why and How does making a model improve you *technology outcomes?* What attribute/ feature is the most important why? What is the best bit of your design? What is your favourite part of the design/outcome? **Notice:** detail in designs, ability to draw in 3D and annotate design ideas Use modelling to inform technology practice and improve *technology outcomes* Understand how modelling helps improve *technology outcomes* Ensure design reflect required or desired attributes Students drawing on relevant information from unexpected sources	**Ask:** What are the best features of this *drawing/ model/ outcome?* Why do you think this? If you/ they were to redo this or make improvements, what changes should you/ they make? Why? Can you make your plan? What help might you need? **Notice:** ability to self and peer evaluate outcomes against established attributes or characteristics Ability to recognise and justify changes for the next iteration of the design	**Ask:** How does working with other people help you? What ideas did you change after talking to *X/group?* What knowledge and skills did you know that the others didn't know and that helped your group? How can other people help you make your design? **Notice:** ability to work collaboratively with others Ability to engage in intercognitive conversations, let own ideas go if necessary and move to new thinking with others Embrace knowledge and skills brought to the group by others Listening to others for ideas

Technological Knowledge				
Resilience: TM	Transference: TM	Flexibility & Sophistication: TM	Reflection: TM	Socialisation: TM
Ask: How many times will you make a model to get the best *technological outcome*? How many times do you think you can make a model to get the best *technological outcome*? **Notice:** making more than one model to improve the designed outcome	**Ask:** What have we already learned from making a model that will help us make our designs better? How did making a model of your design help make it better? **Notice:** recognition of the different forms of modelling such as functional modelling and prototype	**Ask:** What changes to your design occurred because you made a model first? How did making a model of your design help you? What is a functional model? Why is functional modelling important to making technology? What is prototype? Why do some technologists make a prototype? What forms of technological modelling (such as draft drawings, final drawing, pattern) have been done for this outcome, and why were they done? **Notice:** increased vocabulary use when describing modelling technology outcomes Correct use of term model and prototype	**Ask:** Next time you make this *technology* what changes would you make? Why? Why were these forms of technological modelling (such as draft drawings, final drawing, pattern) you have been done for this *technological outcome*? What forms of modelling might have been used to create this technological outcome? **Notice:** use of attributes to evaluate design modelling Identify who might use a *technology* and why? Comparing of their outcomes with pre-determined attributes Ability to undertake self and peer assessment against identified attributes	**Ask:** How do you think the designers of this *technological outcome* modelled their ideas? How did this modelling help you design and make this technological outcome? **Notice:** conversations in groups that recognise design faults due to undertaking modelling

Resilience: TS	Transference: TS	Flexibility & Sophistication: TS	Reflection: TS	Socialisation: TS
Ask: How can you make your system better? What changes to this system would you make next time? **Notice:** ability to continue working on problem solving or developing a system repeatedly after failure such as debugging a computer programme Ability to name alternative inputs in a system and how they might impact on outputs Independently noticing changes in outputs when inputs are changed	**Ask:** What groups of people may not like this *technological system?* What are the main tasks for a technologist (a person who designs stuff) a system? What have we already learned that will help us to design this system? **Notice:** key concepts about systems transferred from one project to the next Tasks that are identified in real *technology practice* transferred to students' technology practice, Draw a flow chart to depict a simple system	**Ask:** How did changing this input change the output? In this simple technological systems how does this component help the inputs to be changed into the outputs? **Notice:** increased vocabulary use when describing technology systems Increasingly complex depicting systems Identification of the components of a technological system and how they are connected Identification of the input/s and output/s of particular technological systems Recognition that a system links components that transform an input to an output	**Ask:** If you add or change this input, how will it change that output? **Notice:** describing of the inputs and outputs of a *technological system* they are making	**Ask:** Who will benefit most from this system? How can you design the system so others will benefit? **Notice:** students working collaboratively to determine system inputs for a desired output

Resilience: Tp	Transference: Tp	Flexibility & Sophistication: Tp	Reflection: Tp	Socialisation: Tp
Ask: How can you make this better? What changes would you make next time? Who will benefit most from this design? Can you design it so others will benefit? **Notice:** ability to continue working on problem solving or developing a solution repeatedly after failure Ability to name alternative suitable materials used	**Ask:** What groups of people may not like this *technological outcome?* What are the main tasks for a technologist (a person who designs stuff)? What have we already learned that will help us with this design? What other materials might be good for this *technology*? **Notice:** key concepts (these will differ according to curricula) learned in one unit transferred to another Tasks that are identified in real *technology practice* transferred to students' technology practice Increasing complex drawing and modelling skills in subsequent units or projects	**Ask:** What would 'good material' *technology* look/ sound/ smell/ taste/ feel? Why is this *technology* made of this material? **Notice:** describing the physical and functional properties of a material increased vocabulary use when describing material properties of *technologies* Recognition that technologies can be made of increasingly sophisticated materials	**Ask:** What groups of people may not like this *technological outcome*? Why? What groups of people will like this *technological outcome* best*?* Why? Next time you made this what changes would you make? Why? **Notice:** talk about how materials are suited for the *technology outcome* Talk about how properties of a material assist user-friendliness and functionality Talk about how properties of a material decrease user-friendliness and functionality Use of attributes to evaluate suitable materials for their design Identify who might use a *technology* and why? Comparing of their outcomes with pre-determined attributes Ability to undertake self and peer assessment against identified attributes	**Ask:** What groups of people may not like the materials this *technology* is made from? Why? What groups of people will best like this the materials used in this *technology outcome?* Why? Who might help you to learn about the best materials for your *technological outcome*? Who might help you to find the best materials for your *technological outcome*? Who might help us to use the best materials for your *technological outcome*? **Notice:** understanding the many technologies are made of materials which are selected by people and impact on people and the environment

Funding Open Access funding enabled and organized by CAUL and its Member Institutions.

References

Alexander, R. (2008). *Towards dialogic teaching: rethinking classroom talk* (4th ed.). Dialogos.

Bakhtin, M. (Ed.). (1981). *The dialogic imagination* (1994 ed.). University of Texas Press. (1981).

Bloom, B. (Ed.). (1956). *Taxonomy of educational objectives: the classification of educational goals* (1st ed., Vol. 1). Longmans, Green and Co Inc

Buchanan Hill, J. (2016). Questioning techniques: A study of instructional practice. *Peabody Journal of Education, 91*(5), 660–671. https://doi.org/10.1080/0161956X.2016.1227190

Christenbury, L., & Kelly, P. (1983). *Questioning: A path to critical thinking*. ERIC Clearinghouse on Reading and Communication Skills and the National Council of Teachers of English. Retrieved from http://files.eric.ed.gov/fulltext/ED226372.pdf

Clarke, S. (2008). *Active learning through formative assessment*. Hodder Education.

Claxton, G., Chambers, M., Powell, G., & Lucas, B. (2013). *The learning powered school: pioneering 21st-century education*. TLO Limited.

Colognesi, S., Vassart, C., Blondeau, B., & Coertjens, L. (2020). Formative peer assessment to enhance primary school pupils' oral skills: Comparison of written feedback without discussion or oral feedback during a discussion. *Studies in Educational Evaluation, 67*, 100917. https://doi.org/10.1016/j.stueduc.2020.100917

Doyle, A., Seery, N., Canty, D., & Buckley, J. (2019). Agendas, influences, and capability: Perspectives on practice in design and technology education. *International Journal of Technology and Design Education, 29*(1), 143–159.

Eason, S. H., Nelson, A. E., Dearing, E., & Levine, S. C. (2021). Facilitating young children's numeracy talk in play: The role of parent prompts. *Journal of Experimental Child Psychology, 207*, 105124. https://doi.org/10.1016/j.jecp.2021.105124

Edwards-Groves, C., & Davidson, C. (2020). Metatalk for a dialogic turn in the first years of schooling. In N. Mercer, R. Wegerif, & L. Major (Eds.), *The Routledge International Handbook of Research on Dialogic Education* (pp. 125–138). Routledge.

Elder, L., & Paul, R. (2007). Critical thinking: The art of Socratic questioning. *Journal of Developmental Education, 31*(2), 32–33.

Fernandez-Cardenas, J. M., & Reyes-Angona, S. (2020). Dialogic educational approaches in Ibero-American countries: A systematic mapping review. In N. Mercer, R. Wegerif, & L. Major (Eds.), *The Routledge International Handbook of Research on Dialogic Education* (pp. 100–118). Routledge.

Fox-Turnbull, W. H. (2017). Enhancing teachers' understanding of young students' learning in technology. PATT 34 Conference, Millersville University, PA, USA.

Fox-Turnbull, W. (2016). The nature of primary students' conversation in technology education. *International Journal of Technology and Design Education, 26*(1), 21–41.

Fox-Turnbull, W. H. (2018). Assisting teachers' understanding of student learning in technology. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-018-948

Fox-Turnbull, W., & Swathi, R. R. (2020). Talking and understanding technology in the primary setting. *Design and Technology Education: An International Journal, 25*(2), 98–100.

Juuti, K., Loukomies, A., & Lavonen, J. (2020). Interest in dialogic and non-dialogic teacher talk situations in middle school science classroom. *International Journal of Science and Mathematics Education, 18*(8), 1531–1546. https://doi.org/10.1007/s10763-019-10031-2

Lantolf, J. P. (2010). Introducing sociocultural theory. 26. Retrieved 18 January 2011, from http://fds.oup.com/www.oup.com/pdf/elt/catalogue/0-19-442160-0-a.pdf

Larrain, A., Howe, C., & Freire, P. (2018). More is not necessarily better: Curriculum materials support the impact of classroom argumentative dialogue in science teaching on content knowledge. *Research in Science & Technological Education, 36*(3), 282–301. https://doi.org/10.1080/02635143.2017.1408581

Liang, W., & Fung, D. (2020). Development and evaluation of a WebQuest-based teaching programme: Students' use of exploratory talk to exercise critical thinking. *International Journal of Educational Research, 104*, 101652. https://doi.org/10.1016/j.ijer.2020.101652

Mercer, N., & Littleton, K. (2007). *Dialogue and the development of children's thinking- a sociocultural approach*. Routledge.

Ministry of Education. (2007). *The New Zealand curriculum*. Learning Media.

Ministry of Education. (2017). *Technology in the New Zealand Curriculum*. Ministry of Education. Retrieved 20 February from http://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum/Technology

Nappi, J. S. (2017). The importance of questioning in developing critical thinking skills. *Delta Kappa Gamma Bulletin, 84*(1), 30–41.

Paatsch, L., Scull, J., & Nolan, A. (2019). Patterns of teacher talk and children's responses: The influence on young children's oral language. *The Australian Journal of Language and Literacy, 42*(2), 73–86. https://doi.org/10.1007/BF03652028

Sedova, K., Sedlacek, M., Svaricek, R., Majcik, M., Navratilova, J., Drexlerova, A., Kychler, J., & Salamounova, Z. (2019). Do those who talk more learn more? The relationship between student classroom talk and student achievement. *Learning and Instruction, 63*, 101217. https://doi.org/10.1016/j.learninstruc.2019.101217

Shanmugavelu, G., Ariffin, K., Vadivelu, M., Mahayudin, Z., & Sundaram, M. A. R. K. (2020). Questioning Techniques and teachers' role in the classroom. *Shanlax International Journal of Educational Psychology, 8*(4), 45–49. https://doi.org/10.34293/education.v8i4.3260

Skidmore, D. (2020). Dialogism and Education. In N. Mercer, R. Wegerif, & L. Major (Eds.), *The Routledge International Handbook of Research on Dialogic Education.* London: Routledge.

Swathi, R. R., Fox-Turnbull, W. H., Earl Rinehart, S. K., & Calder, N. S. (2020). Development of formative assessment tool for a primary, technology classroom. *Design and Technology Education: an International Journal, 25*(2), 101–116.

Thompson, C. M. (1990). "I make a mark": The significance of talk in young children's artistic development. *Early Childhood Research Quarterly, 5*(2), 215–232. https://doi.org/10.1016/0885-2006(90)90045-3

Wangru, C. (2016). The research on strategies of college English teachers' classroom questioning. *International Education Studies, 9*(8), 144–158.

Warrick, P., & Cook, V. (2020). Classroom Dialogue. In N. Mercer, R. Wegerif, & L. Major (Eds.), *The Routledge International Handbook of Research on Dialogic Education.* London: Routledge.

Webb, N. (1997). *Research Monograph Number 6: Criteria for alignment of expectations and assessments on mathematics and science education*. CCSSO.

Wegerif, R. (2020). Introduction to the theory of dialogic education. In N. Mercer, R. Wegerif, & L. Major (Eds.), *The Routledge International Handbook of Research on Dialogic Education* (pp. 11–13). Routledge.

Wegerif, R., & Major, L. (2019). Buber, educational technology, and the expansion of dialogic space. *AI & SOCIETY, 34*, 109–119. https://doi.org/10.1007/s00146-018-0828-6

Yakubinsky, L., & Eskin, M. (1997). On dialogic speech. *PMLA Publications of the Modern Language Association of America, 112*(2), 243–256. https://doi.org/10.2307/463093