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Research Article

Pedagogical link-making moves implemented by a pre-service teacher to promote classroom talk in a multilingual physics classroom

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Productive talking of science in classrooms, by students, touches on various pertinent issues such as the language of learning and teaching and the teaching strategies teachers choose to use. This is particularly the case in developing countries, such as Lesotho, where teaching and learning resources are scarce. This study employed the concept of pedagogical link-making moves to analyse how a pre-service teacher promoted classroom talk in a physics classroom during a ten-week teaching practice session. The study responds to the research question: Which pedagogical link-making moves did the pre-service teacher opt for when promoting classroom talk in a multilingual physics classroom setting? A pre-service teacher's Grade 10 physics lesson on conduction was video and audio-recorded and analysed following Discourse analysis strategy. The results show that the pre-service teacher engaged different pedagogical link-making moves at both the stages of availing the concept and extending its meaning. It is recommended that teacher training institutions provide pre-service teachers with more opportunities to practise how to promote classroom talk.

Keywords: Classroom talk, Pedagogical link-making moves, Physics lesson, Pre-service teacher

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1. Introduction

The debate around promotion of classroom talk during science lessons (Qhobela & Moru, 2020) touches on several critical aspects of the teaching and learning of science. In particular, it touches on the language of learning and teaching [LOLT] where, for instance, in developing countries, such as Lesotho, teaching and learning is done in a foreign language; English in Lesotho's situation. According to Qhobela and Moru (2020), the use of LOLT, particularly when the language of teaching differs with the mother tongue, calls for special attention by science teachers to support students' learning. Of particular significance is whether mother tongue, as an available psychological tool, available in the science classroom should be ignored. Setati (2005), arguing from a mathematics education perspective, concluded that "It is important that teachers in multilingual classrooms pay attention to how the different languages present in their classrooms can be used to support learners' participation in a range of mathematics Discourses" (p.464). Recent studies show that some science and mathematics teachers in Lesotho tend to use both English and Sesotho, in a form of code switching, in their classes (Qhobela et al., 2024). The curriculum documents in Lesotho have – until recently – reflected promotion of a bilingual education system in which the teaching of all subjects, including all science subjects and mathematics, should be done in English at secondary level. However, the recent language policy document advocated recognition of three Nguni and Sign languages in addition to Sesotho and English (Ministry of Education and Training [MOET], 2019) and which must be included in the curriculum. The policy document maintains the recommendation that teaching and learning at lower

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primary (Grade 1 to 3) must be done in students' mother tongue and then in English from Grade 4 up to tertiary level.

The debate again touches on critical contextual issues related to the teaching and learning of science. In Lesotho, the teaching of science is reported to be faced with numerous challenges (Maqutu, 2003) including lack of laboratories and consumables (George & Kolobe, 2014) and reliance on chalk and talk teaching strategies (Makhechane & Qhobela, 2019; Mohafa et al., 2022) with students hardly given chance to talk except if they ask or respond to the teachers' question(s) (Qhobela & Moru, 2014). According to Mabejane and Ravanis (2018), teacher training at institutions of higher learning such as the National University of Lesotho [NUL] follows a system that promotes fragmentation between subject matter, pedagogy and school practice. The concern about the disjuncture in pre-service training programmes has been reported elsewhere. For instance, Wasanga et al. (2015) acknowledge these challenges institutions of higher learning face and further discussed mentoring, at school level, as one possible remedy that institutions may pursue. A similar observation is made by Hanke et al. (2021) about the teacher training in Germany and suggests a principle called boundary crossing which advocates interlinking in subject matter knowledge [SMK] and its teaching. By induction, pre-service teachers, trained to break the students' silence, may be struggling with the implementation of classroom talk and as a result their students remain silent most of the time during the lesson. A gap exists in the literature regarding the challenges pre-service teachers face when implementing classroom talk in Lesotho physics lessons. This study critically examines pedagogical link-making moves that one pre-service teacher [PST] implemented to promote classroom talk during a physics lesson while on a ten-week teaching practice [TP] session. The study responds to the research question: Which pedagogical link-making moves did the pre-service teacher opt for when promoting classroom talk in a multilingual physics classroom setting?

1.1. Classroom Talk

The notion of classroom talk draws its meaning from the Vygotskian sociocultural theory that views learning as a meaning making process. At the core of the theory is the understanding that development of higher order functions within an individual happens as a result of discursive interactions among participants. One of the critical characteristics of these interactions is the fact that they are predominantly discursive and historical. These interactions are such that "…individual learners must make sense of the talk that surrounds them, relate that talk to their existing ideas and ways of thinking. Learners must reorganise and reconstruct the talk and activities of the social plane" (Leach & Scott, 2003, p.101). One way of viewing these discursive interactions is to recognise that talking aims at establishing intersubjectivity that, according to Msimanga and Lelliot (2014), refers to "…dynamics of how participants recognise, tune in to and tolerate each other and each other's ideas" (p.1164). According to Vygotskian sociocultural theory "…human activities take place in cultural context, are mediated by language and other symbol systems, and can be best understood when investigated in their historical development" (John-Steiner & Mahn, 1996, p.171). Therefore, according to the sociocultural theory, learning is social, cultural, historical, and mediated by language and other symbols. Other researchers have identified different, yet equally important, aspects of Vygotskian sociocultural theory. Wertsch (1991) identified three themes necessary to fully comprehend Vygotskian sociocultural theory. Firstly, it is the notion that individual development originates from the social interaction. Secondly, it is the notion that human action is mediated by tools and signs. Lastly, it is the notion that the individual development can be best understood through genetic analysis.

Scholars have identified features of classroom talk that make it an effective meaning making process. For instance, some scholars argue that classroom talk must be dialogic for it to effectively influence development of meaning (Gillies, 2014; Mortimer & Scott, 2003). According to Gillies (2014), one of the characteristics of dialogic talk is that it must include sharing of ideas by students and by students with the teacher and jointly seek alternative perspectives. Boyd and Markarian (2011) argue that a dialogic talk allows the student to say what he/she knows and interpret it. This leaves the teacher with the main role of listening and guiding the process of link-making between the student's knowledge and the scientific concept (Scott et al., 2011). According to van der Veen et al. (2017), effective dialogic classroom talk includes supporting students to be able to share ideas, listen to each other, reason and think together.

Other researchers have argued that classroom talk must include reasoning and justifying of the viewpoints. According to Sedova et al. (2016), the fact that students in their study were able to improve their talk and arguments suggests that classroom talk contributed significantly to their learning. Rapanta et al. (2023) argue that students' justification of ideas and constructive criticism of others' view-points critically contribute to the development of knowledge. Other researchers have argued for meaning making process enhanced by use of representations.

1.2. Promotion of Classroom Talk

Literature suggests that effective use of classroom talk in science lessons calls for deliberate promotion of productive talk (Gillies, 2014; Hackling et al., 2010). Different researchers have addressed promotion of classroom talk in science classrooms differently (Mortimer & Scott, 2003; Qhobela, 2008). For instance, Mortimer and Scott (2003) proposed that promotion of classroom talk should involve three stages in which a science teacher progressively assists students to talk science. They suggest that:

> "First, the teacher must make scientific ideas available on the social plane of the classroom. Second, the teacher needs to assist students in making sense of, and internalising, those ideas. Finally, the teacher needs to support students in applying the scientific ideas, while gradually handing over responsibility for their use" (p.17).

Kabi et al. (2024) adopted these stages in the teaching of balancing chemical equations to junior secondary students and concluded that the design assisted students both to acquire the register and understand the scientific concept. Qhobela (2008) designed a four-stage study in which access students were introduced to classroom talk. The first stage, Conceptual Foundation, involved students given the opportunity to talk about their prior knowledge. The second stage, Conceptual Initiation, involves students introduced to Discourses of science and to associate these Discourses with the scientific phenomenon. This stage involves an important aspect, ventriloquation (Duran, 1998), in which students start to mimic the teacher's talk. The third stage, Conceptual Formulation, involves students given the opportunity to start practising Discourses of science introduced during Conceptual Initiation stage. During the last stage, Conceptual Application, students were given further opportunity to use Discourses of science as they study application of the phenomenon in artefacts.

A wide range of other approaches for promoting classroom talk have been suggested by other scholars. For instance, Mitchell (2010) proposed several principles of teaching, or actions of the teacher, that can promote classroom talk. These include to "Share intellectual control with students, create occasions when students can work out part (or all) of the content or instructions, provide opportunities for choice and independent decision-making, and promote talk that is exploratory, tentative and hypothetical" (p.175). Michaels and O'Connor (2015) have suggested that teachers can promote classroom talk through at least four moves; by posing a question which will allow students to share, expand and clarify their initial ideas; by encouraging students to listen to one another and take other's ideas seriously; by encouraging deep reasoning; and by encouraging students to understand another's idea and developing it.

1.3. Pedagogical Link-making

The notion of teacher moves to foster understanding of scientific concepts has attracted consideration by science educators for some time (Harris et al., 2012; Scott et al., 2011). Scott et al. (2011) coined the concept of pedagogical link-making as a way of describing how teachers and students make connections between ideas during a science lesson. According to Staarman and Ametller (2017), pedagogical link-making moves are "…ways in which teachers and students make connections between ideas in the ongoing meaning-making interactions of classroom teaching and learning" (p.500). Scott et al. (2011) proposed three forms of pedagogical link-making moves namely: support knowledge building, promote continuity, and encourage emotional engagement. According to them, one is performing a support knowledge-building move if he/she is "…making connections between different kinds of knowledge to support students in developing a deep understanding of subject matter" (p.5). Indicators of supporting knowledge building are in the form of at least six link-making moves: making links between everyday and scientific ways of explaining, making links between scientific concepts, making links between scientific explanations and real world phenomena, making links between modes of representation, moving between different scales and levels of explanation, and analogical link-making.

Promoting continuity comprises making "…links between teaching and learning events occurring at different points in time…" (p.5) and has two indicators of link-making moves: to develop the scientific story, and to manage/organise. Encouraging emotional engagement "…relates to the different ways in which the teacher makes links to encourage a positive emotional response from students to the ongoing teaching and learning" (p.5). Indicators of encouraging emotional engagement are in the form of two link-making moves namely, addressing substantive content, and generic approaches.

Literature highlights the benefits of pedagogical link-making moves during the teaching and learning of scientific concepts. For instance, Aranda et al. (2020) studied Biology teacher moves while teaching genetics and genetic engineering and found that even though there were clear differences in how teachers involved students in classroom discourse patterns, the moves promoted productive talking among students. Soysal and Yilmaz-Tuzun (2021) studied moves engaged by a physics and chemistry teacher and concluded that the science teacher's link-making moves were critical in strengthening the students' talk of scientific concepts.

1.4. The Effective Teaching of Physics

Many researchers in physics education have proposed and investigated various approaches for effective teaching of physics at different levels of schooling. For instance, some scholars have recommended the use of inquiry-based teaching as an effective approach. Fernandez (2017) shows that authentic inquiry-based instruction had a direct relationship with students' performance in thermal physics while Zain and Jumadi (2018) demonstrated that there is a relationship between inquiry-based teaching and development of critical thinking skills. Similarly, Senyigit et al. (2021) demonstrated that the use of simulations, within the inquiry-based approach, effectively addressed misconceptions related to capacitors than traditional lecture methods. Other scholars have suggested the integration of ICTs, such as simulations, as effective ways of teaching physics concepts. For instance, Crook et al. (2015) reported that availing ICTs to students in Australia had a positive impact on attainment in physics concepts and other science subjects. Similarly, Wood and Blevins (2019) demonstrated that the use of simulations in teaching properties of light resulted in similar practical skill development as in practical work.

Other scholars have suggested the use of classroom talk as an effective approach to the teaching of science and, in particular, the teaching of physics (Taylar & Lelliott, 2015). Moje (1995) concluded that engaging classroom talk emphasising the language unique to science can assist students in developing conceptual understanding of scientific concepts. In addition, Seah and Yore (2017) highlighted the potential classroom talk has on the learning of physics concepts at primary school level.

2. Methodology

This study adopted a qualitative approach in which the pedagogical moves made by a physics pre-service teacher who practised promotion of classroom talk in his physics lessons were analysed. The approach allowed the researcher to visit the study site open-minded to observe the patterns in a natural setting as they emerged (Creswell, 2009). The classroom, students and the PST were therefore assumed as critical elements of the natural setting where meanings of observed patterns were sought. In order to achieve this, the study analysed the video and audio records of a physics lesson the PST submitted after teaching practice. This design allowed the researcher to analyse the behaviour, interactions and moves of the PST (Lau & Bratby, 2023) and the interactions of students. Importantly, Tracy (2013) advises that qualitative research becomes ideal when the researcher is interested in uncovering salient issues that may later need attention. Thus, understanding the PST's pedagogical link-making moves became a necessary reflective practice with the potential to inform further training.

2.1. Sample and Sampling

A lesson of one physics pre-service teacher was analysed. The PST was selected because – in a group of 8 physics PSTs in the 2022/2023 academic year – he was the only one the researcher managed to visit and record one of the three lessons he was expected to submit as part of proof of his work during teaching practice. At the time of recording the lessons, the PST had taught physics to the same class for a period of five weeks. The PST is a male and was a 4th year Bachelor of Science Education (BSc. Ed) student with one-year teaching experience from a diploma programme he had done at a different institution before joining NUL for the BSc. Ed programme. The lesson was recorded by the researcher and the PST's mentor. As part of his training at NUL, the PST attended a course on the teaching of physics where classroom talk was introduced. In particular, a discussion of the classroom talk included Mortimer and Scott's (2003) levels of classroom talk and Mortimer et al.'s (2011) pedagogical link-making moves.

2.2. Data Collection

The data analysed in this study emanates from video and audio recordings of a PST's physics lesson and is drawn from a lesson in which a thermal physics concept, conduction, was taught to a Grade 10 class. The lesson duration was 80 minutes and took place in a laboratory. The students were arranged in groups of about 6 and were asked to discuss different aspects of meaning of a scientific concept at different stages of the lesson. The teacher placed audio recorders with two groups chosen randomly. The researcher visited the same class three weeks prior to recording this lesson and sought permission to record lessons, which the management of the school granted. During that visit, two lessons, one in physics and the other in mathematics, were recorded by the researcher.

2.3. Data Analysis

Data analysis followed the Discourse analysis model by Gee (1999). The model proposes that in order to fully appreciate meaning within a conversation, analysis must focus on at least five aspects of a situation namely: Semiotic, Activity, Material, Political and Sociocultural aspects. Gee and Green (1998) argue however, that "…since it is not possible during analysis to consider all of these aspects simultaneously, it is necessary for an analyst to foreground particular aspects while backgrounding others" (p.135). In this study, two aspects are foregrounded. First, it is the activity aspect in which specific social activity or interconnected chains of activities are identified and analysed. The video recording was specifically used to identify the PST's movements and associated activity. He was observed either coming to a group and saying something or calling for students' attention. This study reports cases where he said something to the group or to the whole class. Second, it is the semiotic aspect in which situated meanings and cultural models are studied and interpreted. Analysing such meanings demands careful and purposeful understanding of a text or gestures (Qhobela, 2008). In this current study, the PST's utterances have been classified into categories of pedagogical link-making moves and the meaning of such utterances were established.

3. Findings

The findings show that the PST engaged different pedagogical link moves at both the stages of availing the concept and extending the meaning of concepts. In both cases, the PST supported knowledge building and promoted continuity. Table 1 summarises the findings.

Table 1
PST's pedagogical link-making moves

	Supporting Knowledge Building	*Promoting Continuity*
Availing Scientific Concept	• Making links between scientific concepts • Making links between everyday and scientific talking	• Developing a scientific story • Organising classroom activities
Extending Scientific Concept	• Making links between scientific concepts	• Developing a scientific story (micro scale)

Table 1 highlights a critical aspect related to the PST's ability to employ pedagogical link-making moves in the sense that there are more moves during the first stage, availing of scientific concept, than at the second stage, extending the scientific concept.

3.1. Pedagogical Link-making Moves to Support Availing of the Scientific Concepts

At the stage of availing the scientific concept, the PST relied on students' prior knowledge and observations to avail the concept of conduction. The main pedagogical link-making moves included supporting knowledge building and promoting continuity.

In order to initiate discussions, the PST introduced an activity which had two stages. In the first stage, students were asked to observe the temperature of a metal which in this case was a spoon. They were expected to gently press the spoon onto the cheek and share their observations with each other. Below is the discussion demonstrating the sharing of ideas by group 1 members.

Extract 1

1. ST14: Let's feel the spoon. (*silence*)
2. ST11: What do you feel when you touch the spoon?
3. ST12: Coldness.
4. ST13: Because sometimes you feel the hotness when… (*something fell*).
5. ST15: It's ST16.
6. ST16: No, it's not me.
7. PST: (*addressing whole class*) Ok! I am going to ask one of you to give us ehhh ehhh what you agreed to. Each member will tell us **your conclusion** as a group there, **what you agreed on**. (**bold = translation, *Italics = comment***)

In the extract above, two important issues surfaced. Firstly, from turn 1 to 4, students are sharing their observation about what they felt when "feeling" the temperature of a spoon. They use everyday words, especially in turns 3 and 4 where they differentiate between "coldness" and "hotness", which lacks the necessary scientific accuracy. Secondly, turn 7 shows the PST performing a pedagogical link-making role. The teacher prepares students to develop a scientific story to be related to the whole class later. Thus, the teacher performed a "promoting continuity" role. Again, the PST wanted students to share their observation(s) with other groups, and therefore organised classroom activities in advance. Thus, the pedagogical linking move that the teacher is demonstrating here is promoting continuity (Scott et al., 2011).

The extract below further demonstrates the promotion of continuity.

Extract 2

1. ST47: When I put it here (*pointing at her cheek*) it is cold.
2. ST48: So you did not use this one (*pointing at the back side of her hand*).
3. ST47: Put it here (*pointing at her cheek*) **you will feel it is cold**.
4. ST49: (*given to ST10*)
5. PST: I did not ask you the "why" question, **is it not so?** (*taking to whole class*). You tell others what you felt.
6. ST47: Put it here you will feel it is cold.
7. ST410: It is cold. Because…

In this extract, the PST is directing the students' discussion to what should be observed and not to start explaining their observations. The explanation of the phenomenon will be another level of the discussion according to him. This extract therefore demonstrates how the PST organised the discussion in this group.

The second stage of the activity required students to fill the beaker containing a teaspoon with hot water and observe the temperature of the non-submerged part. The discussion in group 2 went as follows:

Extract 3

1. PST: I am going to ask this class: what do we think is going to happen with that end that is not in contact with hot after maybe 5 minutes? That is what you are discussing now (*talking to whole class)*.
2. ST21: Yes! What's going to happen to this part outside hot water?
3. ST22: When you fill hot water in the beaker?
4. ST21: Not in water?
5. ST22: **No!!** When this part is in hot water.
6. PST: (*arrives at group 2 and interrupts)* Yes, what did you agree on? What will happen to the part outside of hot water?
7. ST22: It will get hot Sir.
8. PST: Yes it will get hot, why?
9. ST23: Because heat here will get transferred to there (*pointing at different parts of the spoon*).
10. ST22: Yes, heat is transferred to here.
11. ST24: Yes, heat will be transferred to that part so that… (*not audible*).

Extract 3 above demonstrates two pedagogical linking moves the PST made. In turn 1, he directed students to what they should talk about. The teacher is again demonstrating the promotion of continuity in that he is directing the discussion towards a specific goal. In turn 9, the PST made his students form a link between scientific concepts; namely that there will be energy transfer and, as a result, the temperature would increase. The PST is therefore encouraging knowledge building. As a result, students used both scientific and non-scientific words. During whole-class discussions, the PST predominantly used question and answer to make students talk about a scientific concept. The extract below illustrates the discussion.

Extract 4

1. PST: ST31 is saying "they vibrate when they move", yes?
2. ST31: Yes.
3. PST: What? Ok! Let us say ST31, you are moving and you are also at a fixed position. Is that possible?
4. ST32: No.

5. PST: Yes let us ehh, let us ehh try to polish that statement. Can we say they are vibrating and also moving? Yes? (*pointing at group 4*)
6. ST41: Sir they are not moving but they are vibrating.
7. PST: They are vibrating at a fixed position.
8. ST41: Yes, at a fixed position.

The teacher started first by putting the idea, from a student, on the social plane so that it was accessible to the other students. Then he dealt with a phrase that was not scientifically accurate. He wanted students to differentiate between "moving" and "vibrating". He is therefore making links between everyday way of talking and the scientific one.

3.2. Pedagogical moves to support extension of the scientific concept meaning

At this stage, the PST used talk to assist students to deepen their understanding of a scientific concept. The main pedagogical link-making moves included both knowledge building and promoting continuity.

The teacher needed students to extend or deepen their understanding of the meaning of 'conduction' after it had been established that "heat/energy moved from one end of the metal (spoon) to another". The discussion below reflects the discussion between the PST and students in group 3.

Extract 5

1. PST: Ok! I am back with the "how" question, but what made the part outside water feel hot?
2. ST31: Sir it will be hot because it is a solid and a solid has free delocalised electrons.
3. PST: It has what?
4. ST31: Free delocalised electron.
5. ST32: Free delocalised delocalised electron Sir (*same time with ST31*).
6. PST: Hmm, ohh.
7. ST32: Yes, that can receive heat.
8. PST: Hmm, that can receive heat?
9. ST32: Yes Sir.
10. PST: And do what with that heat they have received?
11. ST..:.. (*one student is responding but is not audible)*
12. PST: Yes, that is the how part I want you to talk about. (*then he leaves*)

Extract 5 demonstrates a pedagogical link-making move in which the PST is extending understanding of a scientific concept. In particular, in turns 3, 6, 8 and 10, the PST is developing a scientific story at a micro scale while at turn 12 he is organising a classroom discussion. The extract therefore demonstrates promotion of continuity. Extract 6 below demonstrates the PST's discussion with group 4 students.

Extract 6

1. PST: Ok! I am back with the 'why' question. Why did you think this part will be will be ehh will be hot too?
2. ST47: Ok Sir! First, this spoon will be will be…
3. PST: Yes?
4. ST47: It is a steel.
5. PST: Yes it is a steel.
6. ST47: And a steel is metal.
7. PST: Yes it is a metal.
8. ST47: So a metal is a good conductor of heat.
9. PST: And a metal is a good conductor of heat, ok.
10. ST47: So this part will be hotter than before because heat will be transferred from here. From high temperature region to low temperature region.
11. PST: Ok, heat is transferred from high temperature region to a low temperature region.
12. ST47: Yes.
13. PST: **So,** you are saying this part will be hot because this heat has been transferred from a high temperature region to a low temperature region?
14. STs: Yes.
15. PST: I am going to come back with the how part.
16. STs: How?

17. PST: Yes, how does that heat….
18. ST46: How does… (*after PST*)
19. PST: Yes, how does it move from this hot part to this part? (*he then leaves the group*)

In extract 6, the PST is assisting ST47, by providing feedback, to build a scientific argument through making a link between scientific concepts. From turn 15, the PST performs a continuity link-making activity in which he encourages the group to move to the next stage of meaning making. That is, he wants them to move to considering "how heat moves" from a high to a low temperature region. Extract 7 demonstrates the discussion that went on after the PST left the group.

Extract 7

1. ST46: Yes, what do we say? How does it move from here to there?
2. ST47: Remember we said it is transferred from high temperature to low temperature. Then Sir says we should say how.
3. ST46: Yes.
4. ST45: No! I think particles here move from this part to there.
5. ST47: Yes, the hot particles will move and get to this part outside hot water.
6. ST45: Yes, let us write it.
7. ST44: Write what? I did not understand.
8. ST47: No ST44, we said hot particles here move from here to there
9. ST44: No, we said (*at the beginning of the lesson*) when particles are hot they vibrate, you remember?
10. ST47: Yes, when they are hot they vibrate and move to the end here. ST44 **is it not so?**
11. PST: Yes, yes, let us hear what you said (*talking to the whole class*). I would like us to discuss how that heat moved from there inside the part in hot water to the outer part of the spoon because most of you said you think heat energy moves from inside region to outer region and that is correct. So now the question is, how, how is this heat being transferred from hot region to cold region? What I am trying to talk about is (*then draws a diagram on the board and repeats the question*).

The students in the extract above are trying to make meaning of how heat energy travelled from the hot part of the spoon to the cooler part. Inevitably, as demonstrated in the extract, students would come up with opinions and reach some form of intersubjectivity. Unfortunately, the PST, in turn 11, cut short their discussion.

During the lesson, PST had to put the ideas from the students' discussions on the social plane. Here the teacher made important pedagogical moves too. The extract below demonstrates the moves.

Extract 8

1. PST: Ok, I want you to tell us how you felt. Did you all feel it?
2. STs: Yes (*in chorus*).
3. PST: Ok, how are the results with respect to how you felt? This group (*pointing at group 1*) how are the results? (*then goes to the next group*). Yes, how did it feel, that outer side?
4. ST11: It is hot.
5. PST: (*moving to group 2*) Ohh!! That outside is cool. *(to group 2)* How did it feel?
6. ST26: It is cool.
7. PST: (*moving to group 4*) Ohh!! It is cool (*to group 4*) and you?
8. ST41: It is warm.
9. PST: So, no group found that end to be cold. I would like you to discuss what happened.

In extract 8, the PST established if all groups had the same observation before directing them to the next discussion. The PST in this extract, therefore, is demonstrating an important aspect of linking the scientific explanation and the real world phenomena by putting both explanations on the social plane. After moving from one group to another, the PST then said:

> PST: Ok no group found that end to be cold. I would like us to discuss amongst ourselves in 2 minutes what happened to that heat. **Is that so?** (*Moves to group 1 and holds the spoon*) The spoon was like this before (*holding it*). Then you put one end in hot water **is that so?** The end in hot water will become hot, **is that so**? So, the part which is not in hot water becomes hot. I would like you to discuss how does that heat, (*going to the board*) ehh, get transferred from that hot region to the cold region. Now the question is

how? What I am trying to talk is (*drawing on the board*) how has this heat been here transferred from this hot region to the cold region?

After moving from one group to another, the PST gave new instructions to all groups, thus making sure that the discussions were on the same issue. The pedagogical linking that the teacher is demonstrating here is that of promoting continuity through managing the discussions.

4. Discussion

This study sought to examine the pedagogical link-making moves employed by a physics pre-service teacher to promote classroom talk. The study was framed on the understanding that classroom talk promotes effective learning of scientific concepts (Aflalo & Raviv, 2022; Khong et al., 2019) and that the language of learning and teaching is, for both the PST and his students, different from their mother tongue. Challenges that this situation brings to a science classroom are well documented (Oyoo, 2012, 2017; Rollnick, 2000). Inevitably, researching on how PSTs promote productive talking of science concepts becomes indispensable in such environments. Literature demonstrates the importance of teacher discursive moves, especially in the teaching and learning of science (Soysal & Yilmaz-Tuzun, 2021; Tytler & Aranda, 2015). For instance, in the study of types of teacher discursive moves in science classrooms, Soysal and Yilmaz-Tuzun (2021) reported positive gains of the moves in promoting classroom talk. In particular, they show that the teacher's discursive moves promoted deeper understanding of scientific concepts. In the same manner, Khoza and Msimanga (2021) analysed physical science teachers' discursive moves and concluded that they contribute positively towards effective teaching of science. The PST in this study implemented a variety of pedagogical link-making moves intended to promote classroom talk in a physics class. In particular, the PST supported knowledge building and promoted continuity during both the availing and extending of meaning of the scientific concept. The results show that when availing the scientific concept, thermal conduction, the PST relied on making links between scientific concepts and between everyday techniques and scientific ways to support knowledge building. To support continuity, the PST relied on developing a scientific story and – from time to time – organised the classroom activities.

When extending the scientific concept, the PST relied on making students make connections between scientific concepts and on developing the scientific concept at micro level to promote continuity. There are incidences that illustrate productive science talking following the PST's moves. For instance, Extract 7 is a typical example of students' talk after the PST directed them to what they should discuss. The findings suggest the crucial role played by teachers' discursive moves to promote productive talk (Soysal & Yilmaz-Tuzun, 2021) particularly at the stage of initiating talk about scientific concepts that are normally abstract. Literature demonstrates that teacher discursive moves can result in promotion of conceptual understanding of concepts (e.g. Aranda et al., 2020; Basal, 2018; Khong et al., 2019), critical thinking (e.g. Cian & Cook, 2018; Soysal & Yilmaz-Tuzun, 2021) and promotion of students' achievement (Tao & Chen, 2023). Literature further suggest that the impact of the teacher discursive moves critically depends on how they are implemented (e.g. Carpenter et al., 2020; Khoza & Msimanga, 2021; Tytler & Aranda, 2015).

The PST implemented a variety of moves at the stage where the scientific concepts were availed compared to where they were extended. At least two important lessons are revealed. Firstly, the PST – as a novice – had a limited repertoire of moves to enable talk of scientific concepts at abstract level compared to what would be expected from an experienced teacher (Basal, 2018). The fact that there are fewer types of moves at the level of extending the scientific concept illustrates the argument that PSTs' pedagogical content knowledge [PCK] can be expected to be low (Miheso & Mavhunga, 2020). According to refined consensus model [RCM] (Carlson & Daehler, 2019), personal PCK, whether at the level of planning or teaching, develops with experience during planning, practice and reflection.

Secondly, the PST's choice of pedagogical link moves demonstrates the challenges teachers, particularly PSTs, face when they attempt to implement productive classroom talk in their lessons. The results of this study suggest that the PST's effort to practise classroom talk in his physics lesson(s) must have been a challenge. Literature records that teachers, more so in developing countries, often find it challenging and hardly implement classroom talk in their classes. Factors contributing to teachers' challenges when implementing classroom talk include lack of resources (Song et al., 2015). It has been demonstrated, for instance, that the use of ICTs can promote effective science classroom talk (Major et al., 2018; Mercer et al., 2019) but in developing countries, the use of ICTs remains a challenge (Cha et al., 2024; Mhlongo et al., 2023). Another factor contributing towards implementation of classroom talk is the use of the second language as the language of learning and teaching in science classrooms (Mavuru & Ramnarain, 2018; Rollnick, 2000). Other literature sources attribute implementation of the classroom talk to the experience of teachers (Wray &

McDonald, 2025). Michaels and O'Connor (2015) note that "…simply knowing that productive talk is important, and encouraging or mandating that teachers engage their students in evidence-based discussion and argument, is not enough to ensure that it happens" (p.333). It is therefore critical that teachers, from as early as pre-service stage, start to practise promotion of classroom talking.

5. Conclusion and Recommendations

This study examined pedagogical link-making moves implemented by a pre-service teacher who promoted classroom talk in a physics lesson. The findings showed that the PST engaged different pedagogical link moves at both stages where the concepts were availed and their meaning extended. In particular, when supporting knowledge building, he engaged students in making links between scientific concepts and making links between everyday techniques and scientific talk at the stage where the scientific concept was availed. In order to promote continuity, the PST engaged students in developing a scientific story while he organised the classroom activities. At the stage of extending the scientific concept, the PST engaged students in making links between scientific concepts as a way of supporting knowledge building, and promoted continuity through developing a scientific story (micro scale). The moves that the teacher used promoted classroom talk. However, it was observed that more moves were implemented during the stage where the scientific concept was availed compared to the phase where the concept was extended. It is recommended that teacher training institutions provide PSTs with more opportunities to practise how to promote classroom talk.

Data availability: The corresponding author has access to the data supporting the findings of this study upon request.

Declaration of interest: The author has no conflict of interest to declare regarding the content of this article.

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