Journal of Pedagogical Sociology and Psychology
Volume 6, Issue 2, 2024
https://doi.org/10.33902/jpsp.202426566

Research Article

Interaction of initiating prompts and the patterns of student engagement in higher education biology classrooms

Hlologelo C. Khoza and Thato I. Makgata

University of Pretoria, South Africa

Correspondence should be addressed to Hlologelo C. Khoza climant.khoza@up.ac.za
Received 13 January 2024; Revised 2 April 2024; Accepted 12 April 2024

The purpose of this study was to understand the interactions of prompts used to initiate engagement and the resulting student engagement using video-data from one biology lecturer in a semester-long module. This study was informed by the socio-cultural perspectives on learning. The transcripts from video data were divided into interactive episodes. In these episodes, we looked for how the prompts (classified as verbal and non-verbal) interacted to bring student engagement. Findings indicate that the prompts interacted in a variety of ways. Findings indicate that the use of verbal prompts like questions resulted in minimal student engagement. Student engagement was heightened when the lecturer initiated whole-class discussion using both verbal prompts as well as non-verbal prompts in an interactive manner. We discuss the significance of these findings and argue how our approach to looking at student engagement helped us to unpack these succinct findings.

Keywords: Verbal and non-verbal prompts, student engagement, biology, classroom discourse

1. Introduction

One of the challenges associated with higher education science teaching is student engagement (Arnold, 2019). Yet, according to Hymers and Newton (2019), the performance of science students is dependent on the extent to which they are engaged in learning by their lecturer. Scholars who investigate student engagement in higher education science classrooms focus on verbal classroom talk sharing some insights on how lecturers can promote student engagement (Alkhouri et al., 2021; Buma & Nyamupangedengu, 2020; Kranzfelder et al., 2020). One of the findings in Buma and Nyamupangedengu's study (2020) is that open-ended questions can stimulate student engagement with the biology content. Alkhouri et al. (2021) investigated teachers' use of discourse practices in STEM college classrooms. They found that both chemistry and biology instructors use authoritative approaches. Kranzfelder et al. (2020) looked at biology lecturers' discourse strategies in undergraduate courses and found that lecturers mostly asked the students to recall facts rather than asking them to build knowledge. What can be deduced from these studies is that higher education science classrooms are still characterised by lecturers' transfer of information and low levels of student engagement. A gap identified in these studies is that scholars looked at teacher strategies for student engagement as confined to verbal talk. Besides verbal talk, there are certain tools that the lecturer can use to engage students. Such tools, just like questions, can be referred to as prompts given their potential to trigger student engagement (Renninger & Bachrach, 2015). A South African study by Khoza and Nyamupangedengu (2018) found that the opportunities for students to engage with the biology content can be created through the use of teaching and learning activities, printed images, and models. The authors, however, relied on classroom observations using an observation protocol. Furthermore, the authors did not show how the use of verbal prompts (VPs) (e.g. initiating questions) and non-verbal prompts (nVPs) (e.g. diagrams and gestures) differed in terms of the resulting patterns of student engagement. Owing to the affordances of video-data in revealing real-time actions to investigate instructional practices

(DeLiema et al., 2023), we argue that looking at the interaction of VPs and nVPs can shed some light into understanding best practices for promoting student engagement in higher education science classrooms. In this article, we follow up on these gaps and limitations and use video-data from a semester-long biology module to show how both the verbal and non-verbal initiating prompts interacted to promote student engagement. We address the following research questions:

RQ 1) How does the lecturer use verbal and nVP to promote student engagement in a biology higher education classroom?

RQ 2) What insights can be gained about student engagement from the interaction of verbal and nVP as used by the lecturer?

2. Literature Review and Theoretical Framework

2.1. Conceptualising student engagement

In literature, there are various definitions of student engagement. Ramli and Yohana (2018) define student engagement from a socio-cultural perspective by arguing that engagement influences how the students in the classroom think and feel. Halverson and Graham (2019) define student engagement as the extent to which students are involved in their learning. In this study, we adopt Moore and Kearsley's (2011) definition since it covers the forms of student engagement inherent in science classrooms. According to Moore and Kearsley (2011), student engagement is defined by: teacher-student engagement that occurs when the teacher exchanges ideas with students in the course of the lesson, student-student engagement that occurs when students discuss their thoughts on what they are learning, and student-content engagement that occurs when students attempt to make sense of the content at hand. In this study, the teacher is the lecturer who was teaching in higher education.

Student-student engagement as characterised by Helme and Clarke (2001) is seen when students question each other, complete peer utterances, exchange ideas, give explanations, and justify their arguments. Sedova et al. (2019) conducted a study to find out if students who talk learn more. The findings indicated that the engaged students meet learning outcomes. Teacher-student engagement as characterised by Helme and Clarke (2001) is seen when students ask and answer questions, make evaluative comments, contribute ideas, and complete teacher utterances. These indicators of teacher-student engagement are triggered by lecturers' actions or tools used during interaction (Pedler et al., 2020). For example, when a lecturer asks questions that are structured, students can contribute to class discussions (Chin, 2007). As students make contributions to class discussions, they are also engaging with the content at hand. Student-content engagement as characterised by Helme and Clarke (2001) is seen when they verbalise their thinking, concentrate (resist distractions or interruptions), gestures (which in this case is interpreted as externalising thought processes), seek information related to the content and feedback (Hardman, 2019; Helme & Clarke, 2001). This form of engagement can be achieved when lecturers intentionally afford students time to engage with the content during interaction.

2.2. Characterising Verbal and Non-verbal Prompts

Our attempt to characterise prompts as VP and nVP stems from the multimodal perspective that scientific ideas are inscribed in various modes of representations including verbal talk, drawings, pictures and analogies (Dressman & Sadler, 2019; Gilbert, 2010). In terms of VP, we draw from the use of initiating questions and how the lecturer weaves interaction by responding to student contributions – defined in literature as rejoinders (Correnti et al., 2015; Khoza & Msimanga, 2021). The initiating questions are usually characterised by closed-ended and open-ended questions (Hargreaves, 1984) including instructions. Buma and Nyamupangedengu (2020) conceptualised closed-ended questions as questions that prompt short responses from students. On the contrary, open-ended trigger varied responses from students (Kayima & Jakobsen, 2020; Khoza, 2024). As a result, scholars have made a distinction (see for example, Kayima & Jakobsen, 2020) that there is always minimised interaction when closed-ended questions are used and heightened engagement

when teachers use open-ended initiating questions. However, Khoza & Msimanga (2021) conducted a study where they found that the efficacy of the initiating prompts depends on the nature of rejoinder moves used to follow up. Lecturers may also foster engagement through the use of stories. For example, using stories in the early stages of the lesson to first allow students the opportunity to engage with the content before it can be discussed among classroom members (see Khoza & Nyamupangedengu, 2018; Zabel & Gropengiesser, 2015).

The use of nVP is important in the sense that it reinforces or supplements the talk or VP used by the lecturer. Using the multimodal perspective, nVPs are usually regarded as representations that work together to convey scientific ideas (Hall, 2020). As such, students' engagement with a sequence of multimodal representations can help to realise the scientific meanings at a conceptual level. Take for example when a lecturer accompanies talk with a matching gesture (Valenzeno et al., 2003). Put differently, when a lecturer accompanies talk with a gesture that communicates the same idea as talk. According to Taylor (2014), this approach makes it easier for students to make sense of the idea taught by the lecturer. Scholars argue that the use of diagrams, models, pictures, and worksheets enables engagement among classroom members (see Khoza & Nyamupangedengu, 2018). Since science concepts are interrelated, the use of multiple representations (more than one nVP in this case) is desired to better show how one concept builds on another (Ainsworth, 2014). However, no attempts have been made by researchers to study how the VPs and nVPs interact and how this interaction results in student engagement. Our aim in this article is to contribute to this gap and show how the interaction of initiating prompts reveals deeper student engagement patterns.

2.3. Socio-cultural Theory as a Theoretical Framework

This study is underpinned by Vygotsky's (1978) socio-cultural theory. Vygotsky's (1978) socio-cultural theory stresses that the mental functioning of the individual is influenced by the culture in contexts. Within a culture, this theory looks into how the participation of individuals in social interaction and socially organised activities influences their psychological development. Vygotsky (1979) argued that "the social dimension of consciousness is primary in time and in fact and that the individual dimension of consciousness is derivative and secondary" (p. 30). What this means is that learning begins in the inter-psychological plane and proceeds to the intra-psychological plane. Thus, the mental functioning of the individuals is derived from social interaction that happens in the inter-psychological plane. From this theory, we drew from three principles. The first principle is learning as a socially mediated process. According to Wertsch (1993), this principle holds the idea that students construct knowledge of the world from their interaction in socially organised activities and internalising the effects of such social interaction. In this study, the social process of learning happens during student engagement. Such engagement as defined by Moore and Kearsley (2011) involve student-student engagement, student-content engagement, and teacher-student engagement. The second principle is of the teacher as the knowledgeable other in the social plane. According to Vygotsky (1978), there needs to be a person (a teacher in this case) who has more understanding of activities and content than students in the social plane. The teacher plays a role in mediating learning through the use of tools such as talk. In this study, the lecturer mediates learning through the use of prompts which can be verbal or non-verbal as stated above. Since in social learning the knowledgeable other is needed to mediate learning, this study also draws from the principle of the provision of tools by the teacher. According to Vygotsky (1978), teachers provide tools in social interaction for students to exchange ideas and construct meaning. In this study, the tools provided by the lecturer, which can be a VP or nVP, are used to promote student engagement.

3. Research Design and Methodology

This was a qualitative case-study (Cresswell, 2017) positioned within the interpretivist paradigm (Kivunja & Kuyini, 2017). Qualitative research approach allows researchers to understand phenomena in-depth. The phenomenon studied is in classroom interactions.

3.1. Context and Participants

The participant was a lecturer who was teaching third-year Bachelor of Education Biology pre-service teachers at South African University and his 27 students. In this institution, the pre-service teachers first complete the main content modules with the Bachelor of Science students in their first two years. They then proceed to do another semester-long content module at the faculty of education covering several biology topics. This module is designed to bridge the gap between the content done in the science faculty and what needs to be taught in schools. The lecturer who participated in this study was teaching this module. A semester is made up of 14 weeks of teaching with a one-week break in between. The module is allocated four 50-minutes long periods a week.

3.2. Data Collection Process

In this study, data was collected by video recording lectures of the lecturer in a semester-long biology module. The use of video data was to capture the interactions taking place in the classroom. Table 1 shows the number of lectures that were video-recorded, and the focus and duration of each lecture.

Table 1
The focus and duration of the video-recorded lectures

Topic and the focus of the lecture	*Duration (min)*
Cell structure and function	
Cell components and functions	70
The endomembrane system	62
Cell cycle and meiosis	
Cell cycle and mitosis	56
Regulation of cell cycle	43
Meiosis I	64
Meiosis II	45
Human reproduction	
Male reproductive system	57
Female reproductive system	62
Evolution	
Introduction to evolution	44
Human evolution	68
Population ecology	
Populations characteristics	65
Models of population growth	73
Factors affecting population growth	53
Interactions in the environment	46

As can be seen in Table 1, we only focused on lectures and disregarded the practical sessions. We have numbered the lectures continuously for ease of reference.

3.3. Data Analysis Procedures

In analysing the video-data, we followed the following steps:

Step 1: We started by transcribing the video recordings resulting in 15 lecture transcripts. Our interest was on the VP and nVP used by the lecturer. As such, we would also make notes to capture observed non-verbal behaviours.

Step 2: We then divided the transcripts into episodes following the approach described by Buma and Nyamupangedengu (2023). However, in this study, the episodes were sections of the transcripts that showed as our unit of analysis. Table 2 shows only the number of engagement episodes identified in each lecture.

Step 3: We coded each episode to look for initiating prompts (VP or nVP). VPs were classified as either an open-ended question, a close-ended question, instruction or a story. If there was a nVP, we looked at whether it was, for example, a diagram or a gesture.

Step 4: We then coded the rest of the episodes in each transcript by looking at how the lecturer responded to student contributions using Tytler and Aranda's (2015) framework. Concurrently, we coded student contributions using Hardman's (2019) framework. We also coded the nVP in cases where the lecturer used these in the middle of the episode.

Step 5: We looked at how the verbal and non-verbal were used (if any) in each episode. For example, the lecturer will show a diagram and simultaneously ask a question. The overlaps between the use of different prompts reveal that the prompts were used interactively. For example, the lecturer would say "I want you to look at this diagram and tell me what you see or what you can say about this diagram". In cases where there is an arrow pointing to another, the lecturer asked a question without referring to the diagram per se. As such, the question was not asked in such a way that it interacts with the use of a diagram. As students study the diagram projected, the lecturer would further say "So, my question is for you to define reproduction. In this case, the lecturer used a diagram as a non-verbal and still asked a question concerning the diagram and later on asked a question (mostly rephrasing the previous question) but without making an explicit reference to the diagram projected.

4. Results and Discussion

Table 2 shows the prompts that manifested in each episode and the interactions of these prompts.

Table 2
Interactions of initiating prompts in the engagement episodes

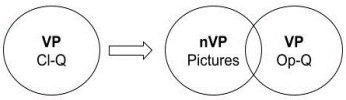
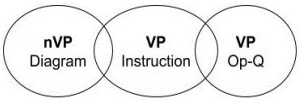
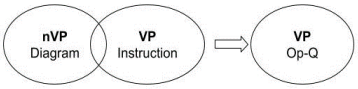
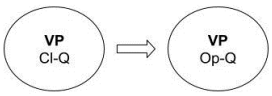
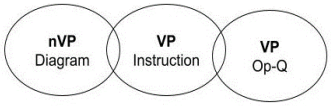
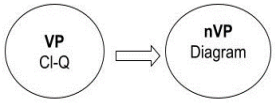
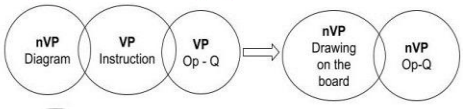
Focus of the lecture	*Identified interaction episodes*	*Interaction of initiating prompts*
Cell components and functions	An overview of microscopy	
	Prokaryotic and Eukaryotic cells	
	Components of eukaryotic cells	
The endomembrane system and cytoplasm	The endomembrane system	
	Organisation of the cytoskeleton	
Cell cycle	Overview of cell cycle	
	The process of mitosis	
	Regulation of cell cycle	

Table 2 continued

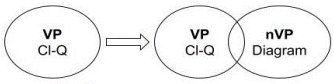
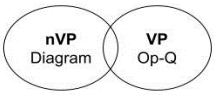
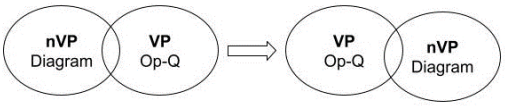
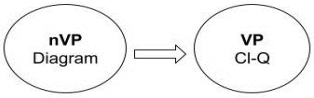
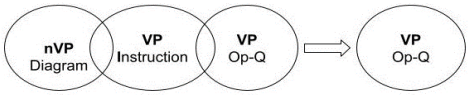
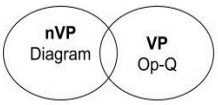
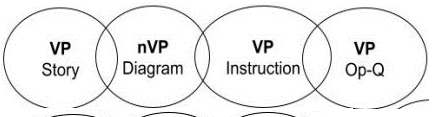
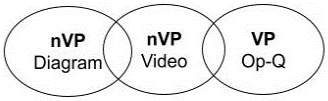
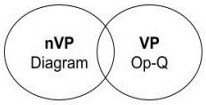
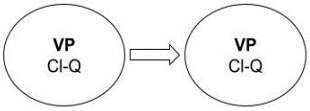
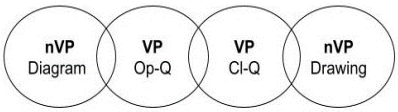
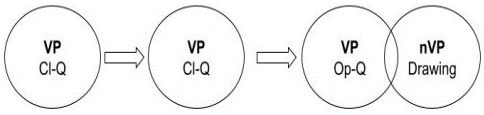
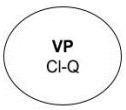
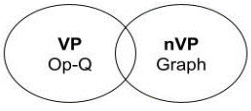
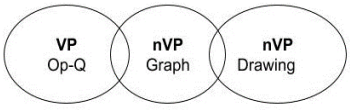
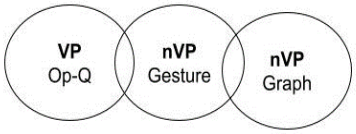
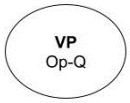
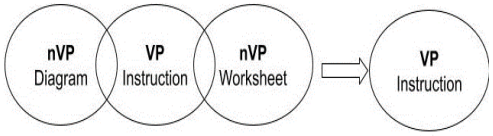
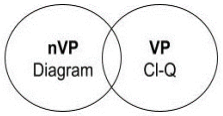
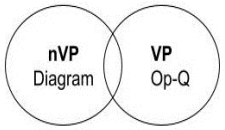
Meiosis	Difference between meiosis and mitosis and the importance of meiosis	
	Overview of meiosis	
	Prophase 1	
	Metaphase I to Telophase I and cytokinesis	
Male reproductive system	Overview of reproduction	
	Parts of male reproductive system and their functions	
	Production of sperms	
Introduction to evolution	Defining evolution	
Human evolution	The concept of adaptation and natural selection	
	Evidence of human evolution	
Populations characteristics	Defining the term population	
	Dispersion as a population characteristic	
	Population density and parameters	
Models of population growth	Defining the concept of a model	
	Estimating population size and rate of increase using the population growth models	
	Further discussion of the two models	

Table 2 continued

Factors affecting population growth	Unpacking density-dependent factors and Density-independent factors	
Interactions in the environment	Defining symbiosis and mutualism	
	Parasitism	
	Commensalism	
	Predation and social interaction	

As can be seen, there were cases where only one VP (question) was used to initiate the discussion. However, in this article, we focus on the use of more than one prompt. An overall observation from this table is that the use of a non-verbal prompt was always accompanied by a verbal prompt – a close-ended question, open-ended question or instruction. This observation is not surprising as Adams et al., (2020) explain that visual representations (taken as nVP) are meaningless if there is no verbal talk through discourse moves accompanying them. Below, we use scenarios to illustrate how these interactions resulted in certain patterns of student engagement. In each scenario, we show example(s) from the lecture transcripts.

4.1. Scenario 1: The use of more than one verbal prompt

There were cases where more than one VP was used. In some cases, the VPs interacted (see episode 1 lecture 2) while in some cases, there was a use of one VP and then a rephrase (see episode 1 lecture 8). The following excerpt is episode 1 of the second lecture. The concept of interest here was the endomembrane system.

(1) Lecturer: So what is an endomembrane system
(silence for 14 seconds)
(2) Student 1: Sir, can you repeat the question?
(3) Lecturer: Okay, let me rephrase, what do you understand by endo and then what about membrane?
(4) Student 1: Ohhh…endo means out…no inside...
(5) Lecturer: And membrane?
(6) Student 2: A cell membrane?
(7) Student 3 It encloses the organelles of the cell.
(8) Lecturer: Anyone else?
(9) Student 4: It's like a system of membranes inside the cell.
(10) Lecturer: Okay that makes sense (writes the student's response on the board). Yes mam?
(11) Student 5: Sir, the cell has a membrane but also the organelles…it refers to the membranes of those organelles as Student 1 said.
(12) Lecturer: Okay good! So which organelles would those be?
(13) Student 5 Maybe the nucleus? It has a nuclear membrane.
(14) Lecturer: Okay, nucleus. Student 6, your hand was up…
(15) Student 6: I wanted to say nucleus sir…in a plant cell, it would be a chloroplast

In the above episode, the lecturer began with a close-ended question which resulted in silence from students. This is evident in turn 2 as Student 1 asked the lecturer to repeat the question. This student's move can be attributed to the fact that the question was asked in a close-ended or procedural manner. As argued by Gillies et al. (2014) and Kayima & Jakobsen (2020), close-ended questions result in authoritative discourses, thus limiting students' thinking to draw from their prior knowledge. Instead of repeating the question, the lecturer rephrased the question in an open-ended manner. This is when students started contributing. In particular, the students were able to begin thinking about what the term endomembrane system could mean because it was broken down by the lecturer and asked in an open-ended manner (see turn 3). The result of this is seen in turns 4-14 as students have a variety of responses (turns 7 and 9) and began to channel their thinking as well as other possible contributions (see Student 6's response in turn 15). This kind of engagement shows students responding as a result of first asking a close-ended question and then asking an open-ended question afterwards. However, engagement was limited as students provided short responses (Hardman, 2019) relying only on the questions asked. In this example, the second prompt (open-ended question) did not interact with the first one (close-ended question). However, because the lecturer was prompted by student silence and a request for clarification of the question, engagement was possible. We observed that even when the lecturer would start with an open-ended question and then a close-ended question, engagement unfolded in a similar manner. For example, in episode 3 in lecture 3, an open-ended question interacted with two other questions (closed and open questions respectively) asked by the lecturer inviting learners to respond. Students were able to associate the term regulation with 'controlling' with the help of the lecturer's elicitation moves Similar to Reiser et al. (2017), we argue that it is not the frequency of questions asked that results in deeper student engagement. Other VPs need to be used to provide students with multiple modalities (Dressman & Sadler, 2019).

4.2. Scenario 2: The use of two prompts - a verbal and a non-verbal

We have found that when there was a VP accompanied by a nVP, the pattern of engagement observed was slightly different from when only VPs were used. We use an example from Episode 4 of Lecture 11 to illustrate this.

(1) Lecturer:	So mutualism… I have given you two examples there. What is happening in the first picture and what is happening in the second picture in terms of mutualism…first picture [depicted in Figure 1]? Yes sir…
(2) Student 1:	First picture is pollination…
(3) Lecturer:	But then what do you mean pollination? How does pollination reflect mutualism?
(4) Student 2:	In the picture, both the organism are benefiting…
(5) Lecturer:	But how?
(6) Student 2:	Sir, it doesn't show in the picture…(laughter from students)
(7) Lecturer:	You can see the flowering plant and you can see that particular insect…an ant…huh? If you we to explain an mutualistic relationship here, what would you say?
(8) Student 3:	If I recall from high school, the bee takes pollen grains to make honey from the flower and then also the bee disperse pollen grain so that the flower can reproduce
(9) Lecturer	Okay! So, what this picture is showing is…(explanation continued)

In the above excerpt, a diagram showing two examples of mutualism was projected for the students to see and an open-ended question was asked about the diagram. The first student to respond to the question referred to the first picture and contributed briefly to the discussion. With the lecturer's follow-up questions in turns 3 and 5, Student 2 was also able to refer to the picture in her brief contribution. However, he was unable to provide an account of how the diagram shows mutualism thus, limiting the extent of engagement. According to Helme and Clarke (2001), engagement is deepened when students are able to justify their responses. Student 3 in turn 8 ultimately draws from his prior knowledge from high school to make connections. In this particular example, the picture, coupled with an open-ended question served as both a reference

Figure 1
Picture used in turn 1 of the excerpt

point and a memory trigger for students to engage. However, as can be seen, the engagement was still limited in the sense that there were no, for example, student arguments, justification and challenges that Hardman (2019) perceives as higher-order student contributions that can drive meaningful dialogic discourse. However, we emphasize the significance picture accompanying the question to elicit student contributions of specific concepts (Khoza, 2024).

4.3. Scenario 3: The use of more than two prompts composed of both verbal and non-verbal prompts

There were many instances where more than two prompts (with at least one nVP) were used by the lecturer to initiate whole-class discussion resulting in student engagement at deeper levels. We illustrate this starting with episode 1 about the overview of reproduction from lecture 5.

(1) Lecturer	Okay. Alright! So, what I want you to do now is to have a look at this (referring to what is on the projector screen) for a minute, try to somehow interpret what you see here. Have a look at that. What is happening in that picture? Alright! Let's hear from student 1, what do you know about reproduction?
(2) Student 1	There is a female and a male plus other 'things' coming out of them…I think these are reproduction cells? Are they cells sir? I mean reproduction cells?
(3) Lecturer	Are you asking me? (Laughter from students)
(4) Student 2	Then the egg from the female and the sperm from the male they fertilize to form zygote. They…
(5) Lecturer	Okay, right there. The sperm from the male right and the egg from the female do what?
(6) Student 2	They go through sexual reproduction and the fertilisation takes place
(7) Lecturer	Now you've changed what you've been saying because you said the sperm and the egg they fertilize which is slightly incorrect… What else can you see Student 3?
(8) Student 3	I can see that the egg has the half of the chromosomes even in the sperm cells. So, they are both haploid.
(9) Lecturer	Where are the chromosomes coming off? Sorry, coming from…
(10) Student 4:	The process of meiosis
(11) Lecturer:	So, they are coming from the process of meiosis. From diploid to haploid. And then what happens next?
(12) Student 5:	The sperm... what the sperm and the egg… when the sperm fertilizes the egg, the embryo…
(13) Lecturer:	You get what?
(14) Student 1:	I think I get what she is trying to say. You get the embryo with the full chromosomes
(15) Lecturer:	The embryo with the full number of chromosomes and in human beings that is 46 chromosomes. Okay. So, what is the difference between this picture (referring to the projected slide) and this picture?
(16) Student 6:	In the picture underneath the 2 cells are joining together and in the picture below one

cell is dividing into 2 cells.

(17) Lecturer: Now, that's key. In this one, 2 cells are… (explanation continues). Here the 2 cells are dividing but what's the difference? Why are they joining here and dividing here? What does that signify?

(18) Student 6: That signifies that fertilisation took place and that mitosis happened

(19) Lecturer: Fertilisation took place here, here there is mitosis happening. Is it the same cells?

(20) Student 1: Yah!... so, they can undergo mitosis (Inaudible)… what am I saying wrong or what am I missing? But what Student 6 said makes sense…

(21) Lecturer: But... ok… so, there's no mitosis here?

(22) Students: No

(23) Student 1: It's meiosis

(24) Lecturer: Why are you lying to me? There's fertilisation there are 46 chromosomes here. Where is this embryo coming from (referring to the projected slide)?

(25) Student 7: Mi…ohhhh sir…no, it is mitosis. I get it now.

(26) Lecturer: Mitosis! So, there is mitosis here? And there is mitosis here but what is the difference?

(27) Student 7: Let me try… mitosis is…(explanation continued)

In this excerpt, the lecturer used both verbal and non-verbal prompts to initiate a discussion. He began by showing a diagram, providing an instruction and asking an open-ended question. These three prompts interacted in the sense that the instruction was based on the diagram and the question was asked with reference to the diagram to initiate a discussion around one scientific idea. Another open-ended question was asked but this question did not necessarily interact with the other prompts used. The result of this initiation was firstly, student extended contributions composed of what Hardman (2019) calls student speculation (turn 2), student explanation (see turn 8), student connect (turn 16) and student recount (see turns 6 and 18). The students were able to display such engagement with the question and the lecturer because there was an instruction regarding what students should do and a diagram that students could refer to. Students got to hear the question in several ways – the use of double moves such that the initiation diverges into different directions but ultimately the targeted concept/idea is attained. Secondly, the students engaged with each other's responses by expanding and justifying. This is visible in turns 14 and 20. Again, Student 1 in turn 14 and 20's ability to add and justify was perpetuated by her peers who provided a foundation for responding to the question in relation to the diagram shown. Thirdly, there is evidence that some students who have been silent since the initiation came on board. For example, Student 7's utterance, "I get it now" (turn 25) then tried to explain the difference between mitosis and meiosis while referring to the picture. Although the focus was not mitosis and meiosis, Student 7 was prompted by the lecturer's use of an extending discourse move in turn 26 as well as what he could see on the diagram displayed. We assume that the student has been cognitively engaged (Khoza & Nyamupangedengu, 2018) with the diagram as well as the question. This is a typical example of a heightened engagement characterised by more student extended contribution where they were able to also show links between what they were learning and other related concepts. Although the lecturer's use of eliciting and extending moves contributed to this engagement, how initiating moves provided a platform for students to think and voice out their thinking. We argue that how the lecturer initiated classroom talk can be linked to what Tang (2017) calls meta-discourse as a scientific resource. In this case, the meta-discourse assisted the students to connect scientific ideas through their contributions.

The second example is from Episode 1 of the first lecture on evolution. The focus here was on defining evolution and providing an overview of it.

(1) Lecturer: So, let me start here (Reads the story alongside a diagram). I just want you to take 30 seconds and read the story yourself. Also, look at the picture here (students then read the paragraph). What can you glean from the paragraph? Anything that you can say about the passage? What is it about?

(2) Student 1: There is something on adaptation and survival but I don't know the difference.

(3) Lecturer: What about adaptation? We will talk about the difference later.
(4) Student 1: Like as it happens, I mean evolution, organisms adapt
(5) Lecturer: Okay that is a good point…we will unpack these later
(6) Student 2: If I am to use the picture, it shows how different organisms are different and you can see links between some of these.
(7) Lecturer: Okay that makes sense. I want you to keep that in mind. It will be useful later. Anyone else?
(8) Student 3: There is variation within species…different
(9) Lecturer: Okay…that is fine. How different? What do you think difference mean here?
(10) Student 3: Those species are developed different.
(11) Lecturer: So organisms are developed differently?
(12) Student 3: Yes
(13) Student 4: So sir, like he is saying (referring to student 3), this difference is variation? I do not know but the picture shows something like that
(14) Lecturer: I don't know also, I want you to unpack this…
(15) Student 5: Also, variation in characteristics and features…
(16) Lecturer: Okay what does that mean?
(17) Student 6 That other organisms would be similar and others way too different
(18) Student 7: I am seeing something about the timeline there
(19) Lecturer: Okay, that is a nice observation…tell us more
(20) Student 1: I wanted to make the same point…that evolution is gradual…like it takes a long time

In this example, the lecturer's initiation was a complete interaction of four prompts beginning with a story and then an open-ended question asked at the end. Again, an instruction that was given by the lecturer regarding a story provided a clearer guideline of what they needed to do. Students had the opportunity to use the story, the diagram or both as a reference point to engage. For example, student 2 in turn 6 explicitly refers to the diagram and justifies it. Another indicator of heightened engagement is in turn 13 when Student 4 contributes to the discussion by referring to Student 3's response in turn 10. As noted by Helme and Clarke (2001), students engage with each other and the content by agreeing and disputing their peers' contributions. Furthermore, to reveal the thinking that has been going on in Student 4's mind, he shows uncertainty or confusion by asking a question of whether the difference that other students are citing in the story and picture is about variation. Although Lodge et al. (2018) argue that student confusion or uncertainty hinders students' conceptual development, this study like that of Nawaz et al. (2020) reveals that it promotes deeper engagement as students need to resolve their cognitive dilemmas around science concepts. In this case, the cognitive dilemma was created by the diagram used. Student 7, who has been quiet notices something about a timeline that had not been voiced out by any other student. This then prompted Student 1 who uttered that she had the same point but extended Student 7's contribution by saying that the timeline reveals the gradual process of evolution. Similar engagement patterns were observed in other cases where the lecturer initiated a discussion by interactively using several prompts. For example, in Episode 3 of lecture 9 where the lecturer used a graph, an open-ended question and a drawing on the board, students began placing several components of the mathematical models of a logistic population growth on the graph. Furthermore, we observed similar interaction patterns where the lecturer used his hands (gestures) to support his questions about the difference between density-dependent and density-independent factors (see episode 1 from lecture 10). Thus, signifying engagement with the graph as a prompt while engaging with each other and the lecturer. This is because diagrams as well as other representations are meaningless when not grounded in content-based questions. Valenzeno (2003) found that in mathematics classrooms teachers who used gestures gained student engagement more than those who did not. According to Evagorou et al. (2015), representations allow epistemic access as students begin to engage in the process of visualization. In this study, we have found that this visualization is brought forth through engagement while responding to the question as a prompt.

5. Conclusions and Recommendations

The purpose of this study was to unpack how initiating prompts (grouped into verbal and nVPs) for engagement interact and the resulting student engagement. We acknowledge the limitation of using one lecturer teaching a variety of topics as a case for demonstrating our argument. One of the key findings is that when a nVP interacted with several other VPs, student engagement was heightened in the sense that this brought silent students to the discussion and students would expand, connect and justify their contributions. We, therefore, recommend that lecturers should begin to not only use VPs but also nVPs interactively to allow deeper student engagement. This would help in mitigating the ongoing challenges around the lack of engagement in classrooms at higher education (Arnold, 2019) or classrooms that are populated with monologic dialigues (Wood et al., 2018). We argue that our methodological approach of grouping the prompts into verbal and non-verbal as well as dividing the transcripts into episodes allowed for a succinct and finer characterisation of student engagement. This is a novel approach that other scholars who look at student engagement can follow.

In this study, we did not analyse the patterns of student engagement as related to topics. Perhaps the use of these prompts in an interactive manner is dependent on the topics taught. We, therefore, call on science education researchers to look into this area as well as the inherent factors that influence lecturers' decisions to use these prompts. This can be investigated through the lens of noticing as Khoza (2022) argues that the enactment of prompts to initiate and weave student engagement is influenced by teachers' pedagogical reasoning and their ability to notice pertinent features of classroom interactions.

Author contributions: All authors have sufficiently contributed to the study, and agreed with the conclusions.

Declaration of interest: No conflict of interest is declared by author.

Ethics statement: This study was approved by the University of Pretoria, Faculty of Education Ethics Committee under the protocol number EDU096/23.

References

Adams, J., Chin, T. Y., & Tan, P. H. (2020). Talking to learn science: Examining the role of teacher talk moves around visual representations to learn science. *Learning: Research and Practice*, *6*(1), 19-33. https://doi.org/10.1080/23735082.2020.1750671

Ainsworth, S., & Newton, L. (2014). Teaching and researching visual representations: Shared vision or divided worlds? *Science teachers' use of visual representations*, *8*, 29-49. https://doi.org/10.1007/978-3-319-06526-7_2

Alkhouri, J. S., Donham, C., Pusey, T. S., Signorini, A., Stivers, A. H., & Kranzfelder, P. (2021). Look who's talking: Teaching and discourse practices across discipline, position, experience, and class size in STEM college classrooms. *BioScience*, *71*(10), 1063-1078. https://doi.org/10.1093/biosci/biab077

Arnold, L. (2019). Accompanying as accomplices: Pedagogies for community engaged learning in sociocultural linguistics. *Language and Linguistics Compass*, *13*(6), e12329. https://doi.org/10.1111/lnc3.12329

Buma, A., & Nyamupangedengu, E. (2020). Investigating teacher talk moves in lessons on basic genetics concepts in a teacher education classroom. *African journal of research in mathematics, Science and Technology Education*, *24*(1), 92-104. https://doi.org/10.1080/18117295.2020.1731647

Buma, A., & Nyamupangedengu, E. (2023). Investigating the quality of enacted pedagogical content knowledge by mapping out component ınteractions: a case study of a teacher educator teaching basic genetics. *Journal of Science Teacher Education*, *34*(8), 1-21. https://doi.org/10.1080/1046560X.2022.2158267

Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching, 44*(6), 815–843. https://doi.org/10.1002/tea.20171

Correnti, R., Stein, M. K., Smith, M., Scherrer, J., McKeown, M., Greeno, J., & Ashley, K. (2015). Improving teaching at scale: Design for the scientific measurement and development of discourse practice. In L. Resnick, C. Asterban, & S. Clarke (Eds.), *Socializing intelligence through academic talk and dialogue* (pp. 315–334). AERA. https://doi.org/10.3102/978-0-935302-43-1_25

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

DeLiema, D., Hufnagle, A., Rao, V. V., Baker, J., Valerie, J., & Kim, J. (2023). Methodological innovations at the intersection of video-based educational research traditions: Reflections on relevance, data selection, and phenomena of interest. *International Journal of Research & Method in Education*, *46*(1), 19-36. https://doi.org/10.1080/1743727X.2021.2011196

Dressman, M., & Sadler, R. W. (Eds.). (2019). *The handbook of informal language learning*. John Wiley & Sons. https://doi.org/10.1002/9781119472384

Evagorou, M., Erduran, S., & Mäntylä, T. (2015). The role of visual representations in scientific practices: from conceptual understanding and knowledge generation to 'seeing'how science works. *International journal of Stem education*, *2*(1), 1-13. https://doi.org/10.1186/s40594-015-0024-x

Gilbert, J. K. (2010, April). The role of visual representations in the learning and teaching of science: An introduction. *Asia-Pacific Forum on Science Learning & Teaching*, *11*(1), 1-19.

Gillies, R. M., Nichols, K., Burgh, G., & Haynes, M. (2014). Primary students' scientific reasoning and discourse during cooperative inquiry-based science activities. *International Journal of Educational Research, 63*, 127–140. https://doi.org/10.1016/j.ijer.2013.01.001

Hall, T. (2020). After the rural idyll: representations of the British countryside as a non-idyllic environment. *Geography*, *105*(1), 6-17. https://doi.org/10.1080/00167487.2020.12094083

Halverson, L. R., & Graham, C. R. (2019). Learner engagement in blended learning environments: A conceptual framework. *Online Learning*, *23*(2), 145-178. https://doi.org/10.24059/olj.v23i2.1481

Hardman, J. (2019). Analysing student talk moves in whole class teaching. *International Handbook on Dialogic Education.* Routledge. https://doi.org/10.4324/9780429441677-14

Hargreaves, D. H. (1984). Teachers' questions: Open, closed and half-open. *Educational Research, 26*(1), 46–51. https://doi.org/10.1080/0013188840260108

Helme, S., & Clarke, D. (2001). Identifying cognitive engagement in the mathematics classroom. *Mathematics Education Research Journal*, *13*(2), 133-153. https://doi.org/10.1007/BF03217103

Hymers, D., & Newton, G. (2019). Investigating student engagement in first-year biology education: A Comparison of major and non-major perception of engagement across different active learning activities. *Canadian Journal for the Scholarship of Teaching and Learning, 10*(1), Article 8. https://doi.org/10.5206/cjsotl-rcacea.2019.1.7993

Kayima, F., & Jakobsen, A. (2020). Exploring the situational adequacy of teacher questions in science classrooms. *Research in Science Education*, *50*(2), 437-467. https://doi.org/10.1007/s11165-018-9696-9

Khoza, H. C. (2023). Teacher noticing as a driver of interaction patterns in science classrooms. *Journal of Pedagogical Research, 7*(1), 53-66. https://doi.org/10.33902/JPR.202318784

Khoza, H. C., & Msimanga, A. (2022). Understanding the nature of questioning and teacher talk moves in interactive classrooms: A case of three South African teachers. *Research in Science Education*, *52*(6), 1717-1734. https://doi.org/10.1007/s11165-021-10024-8

Khoza, H. C., & Nyamupangedengu, E. (2018). Prompts used by biology lecturers in large lecture group settings to promote student interaction. *African Journal of Research in Mathematics, Science and Technology Education*, *22*(3), 386-395. https://doi.org/10.1080/18117295.2018.1542553

Khoza, H. C. (2024). Dialogue with students as a valuable tool in teacher inquiry for professional development: A narrative of a novice science teacher educator learning about student interaction in biology classrooms. *Journal of the Scholarship of Teaching and Learning*, *24*(1), 44-57.

Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of higher education*, *6*(5), 26-41. https://doi.org/10.5430/ijhe.v6n5p26

Kranzfelder, P., Bankers-Fulbright, J. L., García-Ojeda, M. E., Melloy, M., Mohammed, S., & Warfa, A. R. M. (2020). Undergraduate biology instructors still use mostly teacher-centered discourse even when teaching with active learning strategies. *BioScience*, *70*(10), 901-913. https://doi.org/10.1093/biosci/biaa077

Lodge, J. M., Kennedy, G., Lockyer, L., Arguel, A., & Pachman, M. (2018). Understanding difficulties and resulting confusion in learning: An integrative review. *Frontiers in Education, 3,* Article 49. https://doi.org/10.3389/feduc.2018.00049

Moore, M.G., & Kearsley, G. (2011). *Distance Education: A Systems View of Online Learning.* Cengage Learning.

Nawaz, S., Kennedy, G., Bailey, J., & Mead, C. (2020). Moments of confusion in simulation-based learning environments. *Journal of Learning Analytics*, *7*(3), 118-137. https://doi.org/10.18608/jla.2020.73.9

Pedler, M., Hudson, S., & Yeigh, T. (2020). The teachers' role in student engagement: A review. *Australian Journal of Teacher Education*, *45*(3), 48-62. https://doi.org/10.14221/ajte.2020v45n3.4

Ramli, M., & Yohana, M. P. (2018). Classroom Interaction: Teacher and Students Perception on Dialogue in Primary Science Classroom. *Edusains*, *10*(1), 127-134. https://doi.org/10.15408/es.v10i1.8092

Reiser, B. J., Brody, L., Novak, M., Tipton, K., & Sutherland Adams, L. M. (2017). Asking questions. In C. V. Schwarz, C. M. Passmore, & B. J. Reiser (Eds.), Helping students make sense of the world through next generation science and engineering practices (pp. 87–134). NSTA Press

Renninger, K. A., & Bachrach, J. E. (2015). Studying triggers for interest and engagement using observational methods. *Educational Psychologist*, *50*(1), 58-69. https://doi.org/10.1080/00461520.2014.999920

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

Tang, K. S. (2017). Analyzing teachers' use of metadiscourse: The missing element in classroom discourse analysis. *Science Education*, *101*(4), 548-583. https://doi.org/10.1002/sce.21275

Taylor, R. (2014). Meaning between, in and around words, gestures and postures–multimodal meaning-making in children's classroom discourse. *Language and education*, *28*(5), 401-420. https://doi.org/10.1080/09500782.2014.885038

Tytler, R., & Aranda, G. (2015). Expert teachers' discursive moves in science classroom interactive talk. *International Journal of Science and Mathematics Education, 13*(2), 425–446. https://doi.org/10.1007/s10763-015-9617-6

Valenzeno, L., Alibali, M. W., & Klatzky, R. (2003). Teachers' gestures facilitate students' learning: A lesson in symmetry. *Contemporary Educational Psychology*, *28*(2), 187-204. https://doi.org/10.1016/S0361-476X(02)00007-3

Vygotsky, L.S. (1978). *Mind in society: the development of higher psychological processes*. Harvard University Press.

Vygotsky, L. S. (1979). Consciousness as a problem in the psychology of behavior. *Soviet psychology*, *17*(4), 3-35. https://doi.org/10.2753/RPO1061-040517043

Wertsch, J. V. (1993). *Voices of the mind: Sociocultural approach to mediated action*. Harvard University Press. https://doi.org/10.4159/9780674045101

Wood, A. K., Galloway, R. K., Sinclair, C., & Hardy, J. (2018). Teacher-student discourse in active learning lectures: case studies from undergraduate physics. *Teaching in Higher Education*, *23*(7), 818-834. https://doi.org/10.1080/13562517.2017.1421630

Zabel, J., & Gropengiesser, H. (2015). What can narrative contribute to students' understanding of scientific concepts, eg evolution theory?. *Journal of the European Teacher Education Network*, *10*, 136-146.