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Teacher-Student Discourse in Active Learning Lectures: Case Studies from Undergraduate Physics

In this paper we develop knowledge of the discourse that takes place between teacher and students in two large undergraduate classes which use a flipped, active learning approach. In flipped classes students encounter the content through pre-class resources, freeing up class time for more active engagement with the material. This results in increased opportunities for teacher-student interactions which may be beneficial for learning. Our aim here is to explore the nature and purposes of these dialogues. Two case studies from introductory physics classes at the University of Edinburgh are analysed through a sociocultural perspective. Three main purposes of dialogues are observed: 1) Involving students in sense-making, 2) Guided expert modelling and 3) Wonderment questions. We found that the dialogues predominantly use a triadic Initiation, Response, Feedback (IRF) format and are authoritative in nature, but work together to create an interactive learning environment that can be described as 'ideologically dialogic'

Key Words: Lecture, Discourse, Dialogue, Dialogic, Flipped Classroom

Introduction

Past research has recognised the importance of talk in science classrooms (Scott 2008) One focus of these studies has been the role of interactions between teacher and student which have the potential to help students to build on their own and others' thinking (Alexander 2006b), help overcome misunderstandings caused by 'common sense' perspectives (Mercer 2007), develop the language needed for individual thinking in the discipline (Mortimer and Scott 2003), and support the construction of scientific knowledge (Driver et al. 1994).

However, research on teacher-student interactions in undergraduate classes is -limited, typically focusing on the discourse of lecturers, and in particular the types of questions that lecturers use during their exposition (Bamford 2005; Fortanet 2004; Tsui 1992). Such research has tended to be based on traditional, generally monologic lectures. Bamford (2005) for example explores the question/answer sequence in which, through rhetorical questions, the lecturer does both the asking, and answering, while Fortanet (2004), Tsui (1992) and Thompson (1998) present functional classifications of teacher's questions. Student questions have received only a little attention: Pedrosa-de-Jesus and co-workers have investigated how university teachers react to students' questions (Pedrosa-de-Jesus et al. 2012), as well as the type of questions that chemistry undergraduates ask in a range of different higher education science contexts, including lectures (Pedrosa de Jesus*, Almeida, and Watts 2004)

With the increased prevalence of flipped classrooms comes increased and varied opportunities for talk between teacher and students. Thus there is a need for a detailed analysis of these interactions, which may clarify their purpose and nature and the ways in which they could support learning in larger classes. In this paper we aim to develop knowledge of the discourse that takes place between teacher and students in large classes that use a flipped, active learning approach. We explore two large undergraduate, introductory physics classes at the University of Edinburgh (>200 students), that have a history of using research-supported, innovative pedagogy and the "flipped" approach (Bates & Galloway, 2012). We focus particularly on the interactions that take place between the lecturer and students in the public arena, i.e. in front of the whole class, which are therefore part of the learning experience for all the students.

Applying a sociocultural theoretical perspective, we ask:

1. What are the purposes of teacher-student dialogue in large undergraduate physics classes?

2. To what extent can the interactions be described as dialogic or authoritative in nature?

3. How do these interactions support learning?

Flipped Classrooms

Flipped classes, in which students encounter the material through pre-class resources and spend time during the class in deeper engagement with the content, are increasingly common in undergraduate science courses (Abeysekera and Dawson 2015). A flipped classroom can be defined as consisting of three components involving:

- moving most information-transmission teaching out of class;
- using class time for learning activities that are active and social; and
- requiring students to complete pre- and/or post-class activities to fully benefit from in-class work (Abeysekera and Dawson, 2015).

Central to the flipped class approach is that class time is spent on ‘active learning’ which Hake (1998) defines as activities “designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors....”. There is growing evidence (Deslauriers, Schelew, and Wieman 2011; Freeman et al. 2014; Hake 1998; Jensen, Kummer, and Godoy 2015) that undergraduate classes which involve such active learning components are more effective for learning compared to traditional science lectures which are predominantly monologic and didactic in nature. As the definition by Hake indicates, one of the purposes of active learning approaches is to increase the interactions between lecturer and students. In previous work we found that the time spent on teacher-student interactions during flipped introductory physics classes was greater than on any other category of active learning activity, including student-student discussions (Authors 2016). In that work we found that on average 20% of class time was spent on teacher-student interactions and that these interactions were in the form of teacher questions and student questions. In comparison 12% of class time was spent on student-student interactions and 55% was spent on non-interactive activities (i.e. the lecturer talking). We also found that teacher-student interactions were most common during ‘active learning’ sections of the class, but that they were also present in the more traditional lecture style sections of the class. We concluded that research into active learning classes should consider both interactive and non-interactive sections and the way in which they work together to create an effective learning environment. For this, a qualitative characterisation is needed to understand the aims, purposes and nature of lecture-student interactions, which the present work aims to provide. Here we present a case-study analysis of two classes from the 16-class corpus used in the quantitative study.

Dialogues

Research into the role of talk in learning is influenced both by Vygotsky’s ideas about the role of language in children’s development, and more recently by the rediscovery of Bahktin’s work on ‘dialogic’ discourse (Rule 2015). The contrast that

Commented [SC1]: children’s

Bahktin makes between talk that is dialogic and talk that is monologic is increasingly being applied to observations of talk in the classroom (Lyle 2008). Here talk is described as dialogic when it generates emergent and shared meaning, when multiple voices are heard, and when this challenges the asymmetrical power relations created by monologic discourses. In contrast monologic talk tends to privilege pre-established fixed meaning, and to accentuate the power of the teacher, thus stifling students' opportunities for exploring their own ideas. While there is a tacit acknowledgement that in formal education, dialogic talk cannot be a true discussion of equals, as the lecturer is an expert with many years experience (and an assessing role in relation to the students), a dialogic approach can still usefully generate discussions in which students can co-construct meaning.

Initiatives which aim to increase dialogic talk in classrooms, such as Alexander's (2006b) framework for dialogic teaching, and Mercer's (2000) 'thinking together' programme focus on creating opportunities for dialogues with students by allowing different voices to be heard, generating collaborative discussions and building on students' ideas cumulatively (Alexander 2006b, 2006a; Mercer 2000; Wegerif 2013; Wells 2007).

The move toward dialogic teaching is in part a reaction to the observation that much of classroom talk is monologic, focussed on the transmission of knowledge and allowing little opportunity for collaborative talk. This is evidenced by the dominance of the 'Initiation, Response, Feedback' (IRF) discourse structure (Sinclair and Coulthard 1975) which has been criticised for giving the teacher undue power over the interaction through control of both the questions being asked, as well as determining the correctness of the responses (Lemke 1990).

Not everyone is so critical of IRF exchanges; it has been argued that they are essential for the co-construction of cultural knowledge (Newman, Griffin, and Cole 1989) because the teacher has the ultimate responsibility to 'repair' any misunderstandings or incorrect conclusions and that the IRF format can be appropriate for a wide variety of tasks, and can support quite different teaching philosophies (Nassaji and Wells 2000). Further Van Booven (2015) found that dialogues which seemed to be structured in an authoritative way can also include elements which shift the nature of the talk towards a dialogic orientation, by supporting a greater diversity of cognitive processes.

Approach

Interactions in the flipped classroom have generally been conceptualised from a socio-constructivist Vygotskian perspective. Bishop and Verlager (2013) argue that the teacher-student interactions involve a 'zone of proximal development' where a student can achieve more with the help of a more knowledgeable other than they can by themselves. The classroom thus becomes a space of interaction with others around concepts rather than passive transmission of packaged information.

With the increasing prevalence of the flipped classroom in undergraduate science instruction there is now a need for a more detailed analysis of teacher-student interactions which draws on the notions of dialogic talk and dialogic teaching described above. This research therefore aims to develop knowledge of the types of teacher-student interactions that take place in large, active learning classes and the way in which they may support learning.

Our perspective is informed by Mortimer and Scott's (2003) framework for understanding dialogue in science classrooms. Central to this framework is the communicative approach which deals with the nature of the interaction between teacher and student. Four fundamental classes of communicative approach were identified by Mortimer and Scott along two dimensions: a continuum from dialogic to authoritative (roughly equivalent to monologic for this purpose) and another from interactive to non-interactive. Mortimer and Scott define dialogic as discourse which takes into account a range of students' ideas. This is contrasted with authoritative discourse which views all interactions from the perspective of the scientifically validated explanation.

We do, however, acknowledge the differences between the school setting, for which Mortimer and Scott's framework was developed, and the undergraduate context that is of interest in this work. These differences include the large class size (>200 students), the shorter contact time, and that class time is just one element of an instructional design in which students are expected to take greater responsibility for their learning.

To take these factors into account, we additionally follow Ford and Wargo's (2012) approach of 'zooming out', viewing the dialogues as components of a set of classroom activities which can work together to impact students' understanding of scientific concepts. For this perspective we draw on the work of O'Conner and Michaels who make a distinction between the 'structural' nature of the interaction (i.e. patterns of utterances seen in individual teacher-student exchanges) and the 'ideological stance' of the discourse (2007). They argue that a learning environment may be described as 'ideologically dialogic' even when the discourse is linguistically and interactionally monologic. Their definition of dialogic focuses on the value of equal social relationships, intellectual openness and opportunities for creative thought.

Methodology

Context

Two first year (introductory level) courses were studied in this research: Physics 1A, taught in the first semester and Physics 1B, taught in the second semester. The courses are calculus based and typical class sizes are 200–300 students, with a gender ratio of around 80:20 males to females. Approximately half the class are majors, intending to complete a physics degree, with the remaining students being nonmajors from predominantly (but not exclusively) other STEM disciplines. The class is taught as a single section with majors and nonmajors together. It should be noted, that, in terms of prior educational qualifications, the nonmajors are as well qualified as the majors: all members of the class must have satisfied the entrance requirements for the physics degree program.

The courses consist of pre-readings, whole class meetings and small group workshops. The whole class meetings are taught by a single lecturer, without the use of teaching assistants. During the week prior to the class on a given topic students read the course material, delivered through both electronic resources and text books, and complete a short online quiz. The classes on the topic, each approximately 50 minutes long, are then predominantly focused on problem solving and discussions through the use of Peer Instruction (PI) (Mazur 1997) implemented through the use of clickers (electronic voting systems).

Peer Instruction is a multi-step pedagogical approach in which the lecturer first poses a multiple choice question designed to test conceptual understanding, students then think about the problem individually and place their initial vote. If fewer than approximately 80% of the students get the answer correct then they are asked to discuss the problem in small groups and then to re-vote. This is followed by whole class discussion of the question and finally the lecturer concludes and sums up the discussion. For this paper we focus on the teacher-student interactions rather than on the peer interactions which we discussed elsewhere (Author et al. 2014).

A typical class begins with the lecturer showing a ‘word cloud’ of the responses to a pre-lecture quiz question which asks students which topics in the pre-readings they have found difficult. The class will then continue with a short explanation of the areas which students have found most troublesome, followed by a series of Peer-Instruction questions on the topic with increasing difficulty. Typically a class will have between 3 and 5 such PI sequences.

Both of the courses in this study are taught by the same lecturer (RKG, who is both an author on this paper and a physics education researcher); both are large, first year classes, which are held in the same lecture theatre and taught with the same pedagogical approach. RKG was an integral part of the research team (and is second author on this paper), which afforded rich opportunities for reflection and iterative analysis, more so than could be obtained from a limited number of interviews or other submissions. In all cases, primary interpretation of the observations was conducted by the other authors, and the lecturer provided clarifications, explanations, alternative perspectives and 'the view from the classroom'.

Both courses result in very high student satisfaction (from end of semester questionnaires), high retention rates, and high class attendance throughout the course. Student learning is also measured through a standardized concept inventory (Force Concept Inventory) during the first semester giving a learning gain of 0.49+-0.1 which is typical of active learning courses, and higher than courses taught using traditional lectures (Hake 1998)

Data Collection and Analysis

A case study approach was chosen as it provides a useful way to give detailed insights into instruction in practice in a way that is not possible with other methodologies (Stake 1995). In previous work a detailed quantitative characterisation of the activities that took place in eight classes from each of the two courses was reported (Author et al. 2016).

The data from the quantitative analysis was used in the selection of cases studies for the present research. Here one class was taken from each course (1A and 1B), chosen to be representative for the course in terms of the fraction of active learning and representativeness of the dialogues.

Data consisted of video lecture recordings (lecture captures) which were originally created for the students' use and made available through a learning management system. Each video was approximately 50 minutes long with around 10 minutes of this time consisting of teacher-student interactions. Each interaction typically lasted less than 30 seconds and the interactions took place at intervals throughout the class session. Interactions included student initiated interactions as well as teacher initiated dialogues. The episodes of interactions were analysed as described below and key examples of each type were then transcribed.

Analysis used three different 'grain sizes': an utterance (to determine the patterns of discourse); a dialogue segment (to better understand teaching purpose and the communicative approach); and the interlinked set of dialogues and the learning context in which they take place. By bringing together these three units of analysis we aim to give a detailed description of teacher-student interactions in large active learning lectures and explore the way in which they contribute to learning. This analysis took place in an iterative fashion, with each informing, and being informed by, the other.

Utterances

Here each exchange was determined by defining the discursive ‘move’ (Mehan 1979; Sinclair and Coulthard 1975). The possible standard moves are: Initiation (I), normally from the teacher, in the form of a question, Response (R), normally from the student, and then either Evaluation (E) or Feedback/Follow-up (F) from the teacher.

Our analysis was guided by, (but not confined to) two commonly observed forms of interaction in the literature (Nassaji and Wells 2000). The first of these, often referred to as ‘recitation’, or ‘triadic dialogue sequence’ (Lemke 1990) is the ‘Initiation, Response, Feedback’ (IRF) discourse pattern (Mehan 1979; Sinclair and Coulthard 1975)

The second is based on the student questioning patterns described by Lemke (1990) Here we split Lemke’s original categorisation into two types to account for questions that are asked after a prompt from the lecturer and those that are asked spontaneously. IQR is a three part exchange involving teacher initiation (I) i.e. asking for questions or comments, students replying with a question/comment (Q) which the teacher then responds to (R). QR is an exchange initiated by the student, normally in the form of a question (Q), followed by a response from the lecturer (R).

Dialogue Segments

Each interaction was transcribed and detailed descriptions of the teaching purposes of each type of dialogue were developed by the first author. Dialogues were then grouped together according to similarity of purpose and a category title that described the purpose of all dialogues in the group was developed.

These initial categories were refined through discussion with other members of the research team and finally checked with the lecturer in order to confirm that they described his experience of the dialogues. Each dialogue was then analysed using Mortimer and Scott's (2003) classification of communicative approach. Here four classes of communication along two dimensions are proposed - dialogic/authoritative and interactive/non-interactive. In this stage the unit of analysis, and our primary focus in this research, is the entire dialogue segment.

Interlinked dialogues and Context

Finally, at the largest grain size, notes were made about the course design and the structure of pedagogical approaches in our analysis, in order to give more detail about how each of the dialogues fitted into the overall experience of interaction for the students during the course.

Findings

Patterns of Teacher-Student Interactions

Figure 1 shows event maps of the activities that take place during the two case-study classes. The top bar of each graph shows how the class time is split between lecturing (i.e. monologue from the lecturer, perhaps with questions to and from the students) and active learning pedagogy (the Peer Instruction sequence as described earlier). The second horizontal bar shows the teacher-student interactions that are in the IRF format. The term ‘chain IRF’ is used to designate IRF interactions that follow on from each other on the same topic. Finally, the third horizontal bar shows the incidents of student questions, split into two types: questions asked after a prompt from the lecturer (IQR) and questions that are asked unprompted (QR). Transcripts illustrating each type of interaction will be presented in the following section.

Figure 1 here

The event maps illustrate that the majority of the discourse is of the triadic IRF form, that interactions mostly occur during PI sections of the class but may also occur during lecture sections, and that questions from the students are seen in both classes. Nasaji and Wells (2000) observed that triadic dialogue can take a variety of forms, and can be used for a variety of functions. They found that triadic dialogue can be the most common form of interaction even when teachers are attempting to create a more dialogic style of interaction in their classrooms. They also argue that this format can be appropriate for a wide variety of tasks, and can support quite different teaching philosophies. This variation in form and purpose of triadic dialogues is evident in the example transcripts in this article.

For this reason, it is important to analyse both the dialogue and the context within which the dialogue takes place. This includes the purpose (or role) of the dialogue and the way in which it fits into the teaching sequence.

Purposes of Dialogues

During our analysis of the lectures, three main purposes of an episode of dialogue were identified: Involving students in sense-making; Guided expert modeling;

and Wonderment questions. Each of these will be discussed below with example transcripts.

1) Involving Students in Sense-Making

This example (table 1) begins by the lecturer showing the results for a PI question about the work done by a gas (see appendix), which involved interpreting a pressure-volume graph. The lecturer points out that the correct answer -is option B -(7 joules) and asks for student explanations for this choice of answer.

This dialogue uses an IRF format with the lecturer asking a question, receiving an answer and evaluating that answer saying ‘yep’ and ‘yes, exactly’. The dialogue can be described as authoritative interactive as only one student voice is heard, and only an explanation for the correct answer is sought, although the lecturer does add his own explanation for how someone may have reached one of the incorrect answers. However, the lecturer also asks the student to explain how they got to their answer, rather than just accepting the factual response that was given. The use of follow-up questions requiring the student to think about why and how is described by Van Booven (2015). He shows how these additional questions ‘push the students …. to move beyond simple recall (towards higher order cognitive processes)’ and argues that this shifts the dialogue from one that is ostensibly authoritarian in nature towards one with a ‘dialogical orientation’.

While only one student voice is heard in this example, whole class dialogue has the potential to play a part in helping students to make sense of the phenomena being discussed. Turpen and Finkelstein (2010) argue that Peer Instruction, and specifically clicker question explanations, support such sense-making as explanations both enable multiple voices to be heard and model scientific discourse. Indeed, they argue, the more collaborative and discursive the interactions, the more teacher-student interactions are sense-making rather than just answer-making.

However, a teacher needs to balance what is ideal from a theoretical pedagogic perspective and what is achievable in real-life situations. The lecturer of these classes found that when students were called on to give reasons for incorrect options, students were often extremely reluctant to speak and the class became audibly restless. This is possibly because the stronger students, who are already sure of the correct answer felt that their time was being wasted (even though that is probably not true). For this reason, the lecturer found that it is sometimes difficult to keep some of the strongest students invested in PI when there is a lengthy discussion of both correct and incorrect answers.

Table 1 here

2) Guided Expert Thinking/Problem Solving

Not all discourse took place during active learning sections of the class. The transcript in table 2 shows an episode in which the lecturer is talking through a worked example on the board, while asking for student input, during a lecture section of the class.

The communicative approach in this interaction is clearly authoritative interactive taking the form of IRF exchanges, where each answer is evaluated by the lecturer. All questions are closed, have a single correct answer, and the responses given by the students are typically in the form of one word answers. This is in sharp contrast to the transcript from the ‘involving students in sense-making’ example in table 1, in which students generally give detailed explanations. However, it is notable that student responses require an analysis of the physics in the problem (and are therefore not simply recalling facts). Each question leads on to another question as the problem-solving progresses, with the result being a lecturer controlled interaction used to guide students' thinking while demonstrating how to solve a problem.

Table 2 here:

3) Wonderment Questions

The third type of talk that we identified was created when students asked questions that opened up further ideas taught in class. Differentiating between lecturer questions and student questions is useful in our context, particularly as a key aim of interactions in flipped lecture classes is to give the student voice more prominence than is typical in traditional classes.

Chin and Brown (2002) identify two broad categories of questions that students ask in science instruction - 'basic information' questions and 'wonderment' questions. While information questions tend to be closed questions around factual or procedural matters, wonderment questions require an application or extension of the ideas taught in the class. Typical wonderment questions focus on causes rather than facts, on resolving discrepancies or gaps in knowledge, or involve prediction i.e. 'what would happen if...'. A wonderment question can be evidence that a student has understood the material at a basic factual level, and is starting to use it for higher order thinking and reasoning.

In our analysis, the majority of student questions were wonderment questions focusing on predictions, explanations, or resolving discrepancies. The example given below is from a 1A class covering calculation of the tension in a string in a static and dynamic system and takes place during a worked example in which the lecturer highlights how to use a free-body diagram to calculate the tension in a string in a static system. In this example the student asks their question unprompted by the lecturer, but similar questions were observed when the lecturer solicited questions. The enthusiastic and welcoming response from the lecturer in this example was common in all the student questions, as was taking the time to give a detailed response.

Questions, particularly ones which are unprompted, have a different structural form from the IRF dialogues discussed above (Lemke 1990). These dialogues give students the opportunity to have some say over the direction of the discussion, but overall control often remains with the teacher who has responsibility for the scientific correctness of the answer, and who decides which questions to answer, and how long to spend on them.

Questions from students may provide additional opportunities for sense-making by involving students in discussion and generating answers to the question posed. For example, on one occasion the lecturer replaced the example that he had prepared with a student's suggested scenario which was then analysed 'live' with input from the class. In most cases, however, wonderment questions come from very able students, who are asking about subtleties or more advanced material that is beyond the scope of the course. In these cases the lecturer still answers the question but notes that he has to take care not to get too invested in them as time would then be used for something that is perhaps tangential to the course.

Table 3 here:

The transcripts discussed above provide examples of the different purposes of dialogue observed: Involving students in sense-making; Guided expert modeling; and Wonderment questions. These three examples also illustrate the analysis that was carried out on the teacher-student dialogues in the two case-studies classes. This analysis comprised three parts: a characterisation of the individual utterances, the communicative approach in each segment and the purpose of each dialogue. In the following discussion, the ways in which these dialogues work together within the pedagogical context will be considered.

Discussion

Authority and Dialogue

From the examples above, we can see that teacher-student interactions were mostly in the IRF triadic form and can mostly be classed as authoritative. The IRF pattern of discourse has been associated with authoritative, monologic dialogues and is often viewed as an approach to learning consistent with a transmissionist style (Lemke, 1990), as it is the teacher who controls both the direction of the questions and the evaluation of the answers. Others however argue that both monologic and dialogic interactions are necessary in education (Mortimer and Scott 2003; Wells 2007). Taking a more nuanced approach, Van Booven found that while patterns of discourse that can be categorized as wholly ‘authoritative’ or ‘dialogic’ do exist, others exhibit an in-between state, showing the characteristic structure of authoritative discourse, while including elements that lead to a dialogic orientation (Van Booven 2015).

While overall the discourse analysed in this work is authoritative in nature, there are elements which encourage higher order thinking and support deeper learning of the material. Although not dialogic per se, these episodes have an important role to play in learning how to ‘do’ physics.

The ‘involving students in sense-making’ interactions included follow-up questions which pushed the students to think more deeply about their answer while creating opportunities for the student voice, and sometimes multiple student voices to be heard. In the ‘guided expert modeling’ interactions, the lecturer demonstrates the thought processes required for problem solving. By making tacit processes visible to learners, students have the opportunity to observe and then put those processes into practice on their own (Dennen and Burner 2008). This is an often overlooked stage in learning through ‘cognitive apprenticeships’ - where novices learn practical skills first through observation of masters and then through their own practice (Collins, Brown, and Newman 1988). Interactions of this form scaffold students’ expertise in questioning and problem-solving approaches, while also providing support for other elements of the teaching sequence which are more dialogic in nature, such as peer-discussion. The lecturer is also modelling the type of questions that students should be asking for themselves when they solve physics problems. This process of learning to question is valuable as it is an essential component of problem-solving ability (Zoller 1987). The questions asked by students, particularly ones which are unprompted are evidence of a climate of constructive inquiry and as Pedrosa de Jesus (2012) argues, central to many of the fundamental practices of scientific discourse including ‘eliciting explanations, postulating theories, evaluating evidence, justifying reasoning and clarifying doubts’.

Ideologically Dialogic

However, the structural pattern of discourse is only one aspect of interactions that is worth considering. Wells (2007) observed that discourse is often authoritative even in classes which ‘felt’ dialogic in their pedagogical approach. Attempting to explain this inconsistency O’Conner and Michaels make a distinction between the ‘ideological stance’ of the discourse and the ‘structural’ nature of the interaction (O’Connor and Michaels 2007). They argue that discourse that is linguistically and interactionally monologic, can nevertheless be ‘ideologically dialogic’. In this approach discourse is analysed in its epistemological and pedagogic context. Discourse that is ideologically dialogic, may, for example, be controlled by the teacher, but be constructed to incorporate student ideas into a discussion which compares how they relate to the scientific view. Similarly, interactions which are monologic, but which help students to consider and evaluate different explanations for a scientific phenomenon, may also be considered ideologically dialogic (Ford and Wargo 2012). Ford and Wargo (2012) demonstrate, through examples from a biology classroom, that instruction can be ideologically dialogic when it enables students to have a ‘dialogic relation’ with the topic, even if that discourse is structurally monologic. This view counteracts the idea that rote learning will automatically result from IRF discourse patterns. To explore this further, we will consider the wider context within which the interactions discussed earlier take place.

Idioculture

The way in which teachers and students interact in the classroom creates ‘a system of knowledge, beliefs, behaviours, and customs’ which can be described as an *idioculture* (Fine (1987) in Finkelstein (2005)). An idioculture is shared by all members of the group, influencing the nature of their future interactions. In the classes described here, the flipped class implementation, with the pedagogical approach of Peer Instruction, work together to create an idioculture in which the shared system of customs, behaviours and values encouraged and supported dialogues, valued questions, and which allowed the student voice to be heard.

The way that technology is implemented to support the pedagogical approach plays an important role in the creation of this idioculture. Here, clickers enable students to answer questions designed to test their conceptual knowledge, which gives an indication to themselves, to each other and to the lecturer of their level of understanding (Beatty and Gerace 2009). When the results of the vote are shown to the class, the lecturer is 'completing the feedback loop' (Boud and Molloy 2013; Sadler 1989), responding to the students' answers and thus continuing the dialogue that has been created by posing the clicker problem.

This interaction can be seen as a discursive 'move' in a dialogue with the students i.e. it is a direct response to the students' voice as expressed through their clicker voting choices. In this way dialogue is mediated through the clicker technology, even though the interaction is between lecturer and the student group as a whole, rather than individual students. Another discursive 'move' in a dialogue came from the pre-class quiz, where students were asked to note any material that they found confusing or difficult. At the start of the class, the lecturer then produced a word cloud of students' answers and explicitly made connections between this and the material being covered in the lecture, showing that the content is influenced by the responses to this quiz. Teacher-student interactions, then, were guided by the students' voice as expressed through their quiz responses.

Used in this way, technology supports deep learning of science in large lecture theatre classes, -where the layout of the room - the stage for the lecturer and tiered, forward facing seating for the audience - may otherwise provide challenges to generating meaningful interactions.

While many of the dialogues discussed in this paper, when taken in isolation, appear to be authoritative in nature, the idioculture taken together with an analysis of the dialogues discussed above point towards a pedagogic approach which can be described as ‘ideologically dialogic’. Three aspects in particular support this characterisation. Firstly the structure of the flipped classroom enables students to have some influence over how the class time is spent; their answers to the pre-class quiz affect the content of the class, their response to the clicker questions impacts the depth of coverage of the content, and the idioculture that welcomes questions, encourages curiosity, enabling them to pursue an area of interest in more detail. Secondly students’ own explanations are heard and incorporated into the whole-class discussion, which helps students to see that there are often multiple approaches to solving problems, rather than a single correct strategy. Finally, discourse scaffolds students’ approach to problem solving, which, when combined with opportunities to put this into practice supports students to develop a ‘dialogic understanding’ with the topic (Ford and Wargo 2012).

While this points towards an approach that can be described as ideologically dialogic, there is room for improvement; Turpen and Finkelstein (2010) believe that hearing from multiple students during the ‘sense-making’ discourse, particularly if explanations are given by students whose answers were incorrect, is important for deep learning of scientific ideas. This is something we did not observe regularly in the classes discussed here.

Limitations

The case studies presented here give a detailed analysis of the teacher-student interactions in two flipped, undergraduate physics classes. However, as the results are from one subject area, at one institution, taught by the same lecturer, the findings should be considered tentative and may not be generalizable to other flipped classes in different contexts. Nevertheless this work indicates the utility of this approach to exploring teacher-student interactions. It also raises questions about the role of teacher/student interactions in a large class setting, the value and purpose of dialogic interactions in this setting, and the role that technology can play in creating opportunities for dialogue, which would provide fertile ground for further research in this area.

Conclusions

Discussion of teacher-student interactions in the school science literature often makes a binary distinction between discourse which is dialogic, involving multiple students' voices, leading to higher order, generative thinking, compared to dialogue which is authoritative, and which results in single, fixed, often canonical scientific responses. Yet in practice, dialogic talk that fits this description has been hard to achieve, leading some to argue that a more pragmatic and perhaps effective approach would be to encourage higher order 'productive talk' within an authoritative sequence (Chin 2006; Van Booven 2015)

Our analysis of teacher-student interactions in two undergraduate physics classes found that discourse typically followed a triadic IRF pattern and could be considered as authoritative in nature. Yet although these interactions were not dialogic per se they created an interactive learning experience which supported students' development of scientific ideas through involving students in sense-making, modeling expert thinking and encouraging wonderment questions. These activities created opportunities for the student voice, encouraged higher order thinking and welcomed student questions.

We have also shown that understanding teacher-student interaction requires a broader grained approach which includes consideration of the idioculture, the activity structures and the pedagogic stance. This is important as ‘the practices of the classroom are tightly coupled to the new understandings about physics, the nature of learning, and the nature of physics that students develop as part of the class’ (Turpen and Finkelstein 2010). By considering the idioculture together with the ~~the~~ flipped approach, the use of technology and the dialogues between lecture and student we have concluded that the classes in this study may be described as ideologically dialogic, even though the structure of the individual interactions are predominantly monologic.

Future research into dialogic teaching in higher education should consider the extent to which teacher-student dialogue is possible (and desirable), within a large class setting, as well as the way in which the wider context, the teaching sequence and course design may support a dialogic approach. The observations presented in the paper may provide a starting point for this research.

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Appendix

Figure 2 here:

Figure 2: Question on thermodynamics (1), lecture B. Correct answer B. 84% students answered correctly in the first vote.

Table 1: Example of IRF teacher-student interactions from a 1B class. Option B is correct

	Lecturer	Ok, so what did you say, so here's what we said (shows graph), that's an 80% win for option B and roughly equal for A and C as well there. So option B 7 Joules , 7 Joules work done during that expansion.
I	Lecturer	Why is it 7 Joules, how did you calculate that?
	Lecturer	Yep (accepts bid from student to speak)
R	Student	Area under the graph
F,I	Lecturer	Yep, so how did you work that one out?
R	Student	You worked out the triangle 3 times 2 and then the other bit is 2 x 4
F	Lecturer	Yes exactly. So basically you just do this geometrically. What you want is you want the area under this curve, so you work out this triangular area here which is easy to do and then you add it to this oblong area, this rectangular area underneath and what you do is you discover that is 3 Joules under there, and that is 4 Joules under there, you add 3 to 4 you get 7. Option B
F	Lecturer	Yeah, those of you who got 3 Joules there, just did the triangular bit and forgot that the area runs all the way down to the axis here, so you have to add also that rectangular part underneath, you have to add this bit on to the rectangular area, so remember to do that it's not just that little triangle it's the whole area right down to the axis.

Table 2: Example of chain IRF teacher-student interactions from a 1A class

I, I	Lecturer	If we set up a system like that what will happen? Is this a static system?
R	Students (many)	No
F,I	Lecturer	No, What will happen?
R	Student	Slide
F, I	Lecturer	Yeah, it will, it will slide, so that the little mass will descend, because its weight, will pull it down and it applies tension to the string which will pull the big mass along. What can you say about the motion of the masses?
R	Student	Accelerating
F	Lecturer	Accelerating. Yep exactly, the masses will accelerate. The little mass accelerates downwards, the big mass accelerates along the way.

Table 3: Example of teacher-student interactions: Student Question from a 1A class.

	Lecturer	Yes? (Accepts bid from student to speak)
Q	Student	Would it be different if the contact points between the string and the mass were not symmetrical?
R	Lecturer	Ooo what a nice question. Would it be different if the contact points between the string and the mass were not symmetrical? Yes it would actually, because….

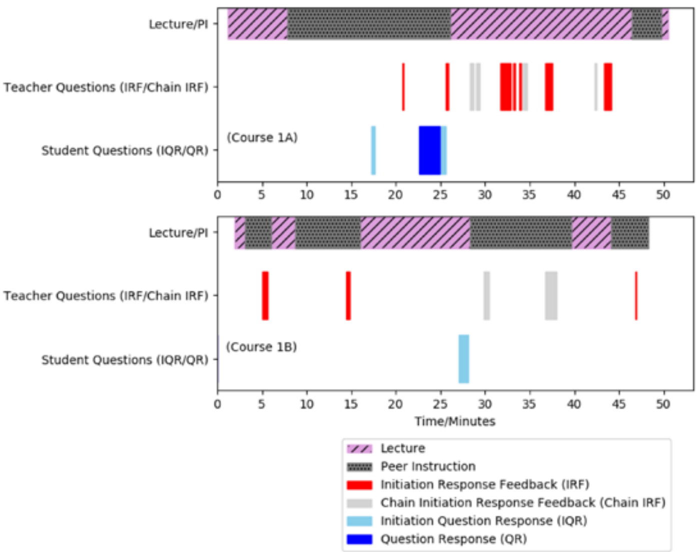

Figure 1: Event map showing instances and type of teacher-student interaction for the case-studies from a 1A class (top) and a 1B class (bottom).