RESEARCH REPORT

How do Physics students respond to a more dialogic approach?

Jacob Breward Butler

University of Cambridge Physics Outreach, Cambridge, UK

Abstract

Background and purpose: Physics is a subject where many groups are under-represented, and is rarely taught in a way that allows students to engage with collaborative, creative problem-solving. Many programmes, including interventions I run, have been developed to address the first issue. However, they have little emphasis on the underlying critical and analytical skills needed to engage with complex, novel ideas.
Aims: This inquiry focused on the ideas of educational dialogue and collaborative learning highlighted in the T-SEDA pack. I focused on the categories "Build on ideas", "Challenge", and "Make reasoning explicit" as these are missing in many Physics lessons. I aimed to encourage Exploratory Talk, defined as a challenge occurring which leads to further discussion, which would show students were engaging with others' ideas.
Study design or methodology: Eight Year-11s from a state-school in Northwest England took part in two remotely-run discussion activities around novel topics. Being able to identify constructive dialogue between students, with little prompting, would show students had engaged in exploratory talk. To measure this, I coded the transcript using T-SEDA guidelines and gave a follow-up interview.
Findings: Students' engagement was good; during 41.5mins and 168 turns of discussion, students spoke for 21.3mins over 77 turns, there were 28 counts of making reasoning explicit, and 10 counts of building on ideas. In the interview, students were unanimously positive and their feedback suggests they understood the session aims and felt they supported their learning.
Conclusions, originality, value and implications: This inquiry suggests students targeted by our Outreach activities view a more dialogic approach positively and benefit from it. To develop this, a larger number of students will take part in similar sessions to determine whether this is more generally true. Sessions will be structured with the aim of teachers continuing elements of this in their own practice.

Keywords: Physics; Science; Outreach; Widening Participation; Dialogue; Practitioner Research; Collaborative Learning; T-SEDA; KS4; Secondary

Summary

A dialogic session was run with eight Year 11 students from a state school in the North West of England. It aimed to introduce them to a more dialogic method of teaching through two discussion activities around topics that would be novel to them, and then gauge their

experience of this through analysis of the transcript and student feedback. The session was run over Zoom, with the students and teacher in one classroom, and led remotely by Jacob Butler. The students responded very positively to the activity, engaging well with a little encouragement, and offered interesting accounts of their classroom experience relating to how they would prefer a more dialogic approach.

My context

The students were Year 11 (age 15-16), four female and four male, from a variety of ethnic backgrounds, and from the same mixed state-school in North West England. They were identified by their teacher as those most able and having an interest in Physics beyond GCSE. The school catchment area includes many deprived areas, around 15% of students are eligible for Free School Meals, and has little uptake to higher education, ranging from quintile 1-3 in the Office for Students metrics (Office for Students, 2019). It has been targeted for interventions by Cambridge University outreach initiatives in the past and students from this school have attended events I have run in Cambridge.

My motivation for the inquiry, focus and inquiry questions

Physics is a subject in which many groups are consistently under-represented; in 2020 around three times as many boys as girls took physics across the UK, with similar ratios for Black students to White students and most to least deprived (Institute of Physics, 2020). It is a subject that requires collaborative and creative problem-solving but is rarely taught in a way that allows students to appreciate or engage with this. Many programmes, such as Isaac Physics (Isaac Physics, n.d.) and the interventions I run, have been developed to address this issue. However, these largely focus on mathematical or experimental applications, with little emphasis on the underlying critical and analytical skills needed to engage with complex, novel Physics exercises.

For example, state-school students often struggle when faced with problems that are specifically chosen to be unknown to them in the interview process at highly-selective universities, such as Cambridge, despite strong exam results (Cambridge Admissions Office, 2019). This points to an issue with students' ability to manipulate and extrapolate from the knowledge they are given during their pre-university education. Coultas (2015) holds that "human learning is specifically social in nature" and points to the importance of students talking through ideas. The way Physics is taught in the UK rarely allows for this sort of interaction to take place so my motivation was to run a session structured around open discussion to see how Year 11 students would respond. My background is in Physics and Philosophy, and the interaction between these two subjects interests me greatly. I feel a more open, seminar-style approach to teaching the logical underpinnings of Physics would help students' understanding, and hope to see evidence of that here.

The main challenge to projects like this is the short timeframe over which Outreach interventions take place. Students attend our events for up to a day and will typically only

attend one event each year. This is in stark contrast to the long-term, embedded approach under which interventions like this have shown success before (Mercer et al., 2019). As such, this project is intended as a smallscale investigation into the potential benefits of a larger Outreach initiative with greater emphasis on teacher engagement. In addition, 2020 was characterised by the COVID-19 pandemic which resulted in the cancellation of all face-to-face events and a complete rewrite of how our programmes were run. This severely limited the opportunities for running the project and it was only completed thanks to the good-will and efforts of my teacher contact.

As another side effect of the pandemic, I was unable to run a preliminary session for the purpose of self-auditing. Analysis of the session transcript highlighted issues with my practice that would no doubt have been apparent in this audit, so I would stress the importance of this process.

The inquiry focused on the ideas of educational dialogue and collaborative learning highlighted in the T-SEDA pack (Vrikki et al., 2019). In particular, the dialogue categories "Build on ideas", "Challenge", and "Make reasoning explicit" were focused upon as, from my conversations with students, these typify interactions that are missing in many Physics lessons. The structure of the project was based around encouraging Exploratory Talk, defined as a challenge occurring which leads to further discussion (Davies & Meissel, 2015), which would show that students were engaging with others' ideas. The inquiry took the form of a Physics exercise, as this is most relevant to my practice and, as discussed, is a subject that traditionally has little emphasis on dialogue.

When developing this inquiry, Quality Talk and the focus on student-led interactions in Davies and Meissel's work was most influential. In the Outreach activities I have run, it is common to find students unwilling or unable to engage with concepts outside their direct learning, even though directed questioning shows they are more than capable of addressing them. My hope was that, by providing the students with an open platform for discussion, they would feel more comfortable expressing uncertain ideas and exploring them with their colleagues.

This requires a careful balance of teacher direction and student freedom. Davies (2015) highlights the importance of allowing students to "hold the floor for extended periods of time" (pg358) and have control over "interpretive authority and turn-taking"(pg342) in order to "take responsibility for co-constructing their own interpretation"(pg344), while the teacher encourages discussion with minimal direction. This differed greatly from my previous practice, which focused on guiding students to a certain idea and laid the groundwork for more productive discussion to take place.

This article (Davies & Meissel, 2015) also provided a pedagogical framework for the session, based around three principles:

(1) using rich, interesting texts that permit a variety of interpretations, opinions, or positions and about which students have some background knowledge;
(2) collaboratively establishing norms or ground rules for discussions; and

(3) initiating discussion by asking a 'big question'—a question of central importance to understanding the text that has no known answer, and about which students' opinions may differ.

Davies and Meissel's project applied these principles in English lessons, so required some adaptation, namely: changing "text" for topic, in this case the life cycle of stars was of particular interest to the students; and instead of a topic with "no known answer", I introduced a topic new to the students but that required no additional knowledge; here dimensional analysis. Davies and Meissel identified small groups of heterogenous students as being the most likely to engage in dialogue, which guided the choice of group size for the inquiry.

Mercer et al. (2019) also emphasise the importance of ground rules for fostering dialogue, advocating for "Talk Lessons" in which these rules are set out so that they can be applied to other classes. This is within the context of a long-term, embedded project but provides an example of how a short Outreach intervention could provide the groundwork for teachers to make use of dialogic practices in their own lessons. Their notion of "Exploratory Talk", defined as when "participants pool ideas, opinions and information, and think aloud together to create new meanings, knowledge and understanding" (Mercer et al., 2019), identified the sort of student discussion that would indicate a dialogic interaction had taken place. This highlights how this approach can be useful in Physics, where students often struggle with deeper understanding of the topics they cover. The idea of high achieving students acting more as intellectual "sponges", who take in information but are unable or unwilling to apply it in novel ways, was brought up in discussions with the teacher and has some evidence here in the discussion transcript.

Finally, Coultas' (2015) emphasis of the importance of "Oracy", the oratory equivalent to literacy, and students' home experiences provided the philosophical mindset with which I approached the inquiry. Coultas sets up a dichotomy between the corrective talk often used by teachers and a democratic sharing of ideas, with an emphasis on how this disproportionately affects "working class" students from deprived backgrounds. A democratic atmosphere is key to overcoming the reluctance of students to put forward their own uncertain thoughts and is central to the open discussion this inquiry aimed to produce.

Coultas notes the emphasis on formal, "standard" English in current government syllabuses, which is a very different mode of communication to the informal discussion between students and contrasts with the regional accents the students involved have. As a white male with a more "standard" accent, who represents a very established institution, this made clear the importance of developing an informal atmosphere during the session, in which the typical formal style of classroom interaction was not required or expected.

Due to the small scale of this project it is not possible to draw general conclusions, so the inquiry question was chosen to be open with the intention of using findings to direct future development of activities; leading to the question "How do Physics students respond to a more dialogic approach?".

As discussed earlier, I hoped to see constructive dialogue between students, typified by challenging ideas, making reasoning explicit, and building on the ideas of others. Being able to identify these dialogic structures occurring, with little prompting, would show the students had engaged in exploratory talk. Success would be measured by observing these dialogic structures and from students reporting a relevant positive experience of the activity.

My inquiry plan and activities

To address the question, a discussion session was held with the students, in which they were presented with novel problems and invited to engage in discussion. This had the following structure, (See Appendix A for detail):

(1) Introductions, in which students decided what pudding they would choose if they could only ever eat one type, to help set an informal tone.
(2) Deciding the ground rules for discussion. This idea was taken from Davies and Meissel's (2015) work, and intended to make clear the dialogic nature of the session and highlight any concerns the students had about sharing their ideas.
(3) A short discussion, in pairs, around how students would choose to measure the age of the Sun. This aimed to gently introduce a more dialogic approach by being tied into the students' interests and allowing them to present or challenge ideas as groups.
(4) The main discussion session, around the question "What are the most fundamental units in Physics?". This aimed to challenge the students with a novel concept, dimensional analysis, that built on their Physics lessons. My hope was that this would democratise the discussion, as no individual student would know the topic, and require that the students worked together to think more deeply about the concepts they had been taught.
(5) Students' reflection on the session, prompted by my questions. This was intended to gauge students' response to the discussions and their experiences of dialogue in the classroom, particularly what might help or hinder this

Change was measured from analysis of the transcript alongside student, teacher, and my own self-reporting feedback. A follow-up questionnaire was sent to the students, but experience shows that these are rarely completed and, as the session took place close to the Christmas break, it is unlikely that more data will be given.

The T-SEDA pack provided the ideas of educational dialogue and collaborative learning, which guided the development of this inquiry, and the codes "Build on ideas", "Challenge", and "Make reasoning explicit" gave focus to the types of interaction it aimed to produce. Template 2A, for coding an audio/video transcript, was used to identify these codes in the transcript.

Ethical considerations and relationships with others

The project was a voluntary exercise with a small number of students, so the ethical considerations of school cohorts missing out on a positive intervention did not apply here. Year 11 students are in a key period, with A-level choices and final exams approaching, so it was important to ensure they benefitted from the session. I discussed this with their teacher and added a Higher Education & university Physics Q&A session, and ensured that the topics covered would be useful in their future studies.

Regarding COVID-19, I worked with the school to ensure that the students' possible exposure was minimised, running the event remotely with a small group in a large room, and meeting all their COVID guidelines. The BERA Ethical Guidelines were followed throughout the project. The students were informed in my introduction of the aims and structure of the overall project and how this session would fit into it, following Guideline 9, and that they would be anonymised for the final report. Their teacher secured consent forms from students and their parents, and made them aware that they could withdraw consent at any time. The data from this study will be password protected and available only to me.

The teacher has an interest in similar research and viewed the session as part of their widening participation activities. We have previously developed new Outreach initiatives together, so communication was straightforward, and their handling of the school's administration was integral to the project going ahead. Through my work, I have spoken to many teachers who are similarly motivated to find new ways to engage their students and I would look to them for any future development of this project.

The volunteers were keen Physics students who had taken part in Outreach interventions before, welcomed the discussion and had many questions for the Q&A session that followed. My participation in this PPD programme is funded by my employer and my manager is keen that the Outreach Office develop new ways to engage with students like these, so there were no issues with stakeholders within my workplace.

My findings

The students' engagement with the discussion session was good; during the 41.5mins and 168 turns of discussion the students were speaking for 21.3mins over 77 turns, there were 28 counts of students making their reasoning explicit and 10 counts of students building on ideas, using the definitions given in the T-SEDA pack (Vrikki et al., 2019). In the feedback during the session, students were unanimously positive, stating that they found the session "really good" and "really interesting".

The students were very aware of each other's input, with many referring to other's ideas in their own thoughts outside of the 10 clear examples of building on ideas, but they were much more reluctant to challenge. Only two challenges were made; one was an interesting challenge to the reductionist ideas underpinning dimensional analysis and the other was a challenge to the consensus of the group. Interestingly, this came from one of the

female students and was built on her contribution to the ground rules, in which she suggested that it is important to play “devil’s advocate” to explore ideas more fully. In line with the reluctance to challenge one another’s ideas, the students did not question me when I made a clear error, highlighting the importance of making them aware this is expected and encouraged.

After the teacher asked whether they were a “stultifying presence” in the room, one student made the following comment:

> “the fact that you're in the room it, sort of, makes you feel like I can’t say things in a certain way. So I have to, sort of, change the way that I'm saying something and then I might not be able to get the full point across because I can't use certain words.”

The teacher then left the room briefly so that the students could talk more freely. This student went on to clarify that the presence of teachers made them feel that they had to “act smarter”, speak more “academically” and that, as a result, they might use the wrong word and hinder their ability to get their ideas across. Physics is a topic with lots of obscure and precise terminology which acts a shorthand to complex ideas. This highlights the importance of teaching in a way that relates vocabulary to the underlying concepts and allows for students that might struggle with terminology alone.

Other students focused on how they felt comfortable discussing the Physics problems and would have issues discussing more controversial topics, such as religion and politics, but there was a notable change in the student’s speaking styles when the teacher left. Despite the students and teacher all having northern accents, the students’ speaking became more relaxed and less formal, “standard” English. This ties with the idea of increasing emphasis on formal speaking in the classroom (Coultas, 2015) and points to a need for dialogic interventions more generally to ensure all students feel able to express their thinking.

Student feedback and analysis of the transcript suggest that these Physics students responded positively to a more dialogic approach. The students stated that they felt it was “good to explore everyone else's viewpoints”, that their colleagues developing their points while respecting what they said “really helps to develop [their] knowledge in that topic”, and that having their ideas challenged made them “think about them in a different perspective”. This suggests the students understood the dialogic aims of the session and felt that they supported their learning.

This was echoed in observations from the teacher, who noted that the “group were noticeably focused and followed intently” through the traditionally taught section that followed the main discussion. From my own observations, there was a marked difference in the way the students responded to closed questions in which a certain answer was expected compared to the open discussion of the session, which suggests a contrast to their typical teacher interactions.

The resource you created

The resource is an outline of an ~1hr session, aimed to introduce students to a dialogic discussion, detailed in Appendix A. This is particularly focused on Outreach practice but could be made more general.

Changes to practice

This project is intended to lay groundwork for future Outreach activities. An additional exercise will be included in one of our upcoming regular programmes and feedback from this will be analysed. Currently, this takes the form of activities that are sent to teachers and completed by them, in their classrooms, so this will have the structure of a "Talk Lesson" focused on a relevant Physics problem. An additional questionnaire will be developed, along with self-reported feedback from teachers.

My reflective evaluation of the process

I was impressed by the readiness of the students to engage in productive discussion, with only a little guidance and direction. The remote format necessitated by COVID-19 was less than ideal, particularly with regards to the quality of recording and ability to observe students' non-verbal interactions, but the students reported a positive experience and were surprisingly enthusiastic about the activities in which they had taken part.

The only disappointment of the inquiry came from an analysis of my practice. When analysing the transcript, it became clear that on several occasions I spoke over students as they reflected on their ideas, did not pick up on interesting ideas that fell outside of the direct focus of the discussion, and did not clarify with students whether I had understood what they said. At one point, this led to me incorrectly telling a student that the units in their answer were wrong, which then produced a short debate in which the students tried to reconcile the contradictions between what I and their teacher had told them.

I was surprised at how much two of the female students engaged with the discussion, taking around 7 turns each compared to the 9 turns of their male colleagues, and that a female student made the only challenge to others' ideas. This contrasts positively with the experience I often have in activities with this age group. Interestingly, the other two female students did not contribute to the discussion at all, despite their teacher describing them as very high achieving. This is more in line with research that shows female students often underestimate their ability and lack confidence in Physics (e.g. (Mujtaba & Reiss, 2016)), and it was disappointing to see that this session failed to connect with them.

As previously mentioned, the teacher has interest in similar research and had previously contacted my workplace regarding our outreach activities. This teacher was essential for the inquiry to progress; they identified student volunteers, managed the school administration requirements, and collected consent forms. Ensuring teachers are engaged with projects is integral to the success of any Outreach intervention.

The greatest external challenge was the COVID-19 pandemic; this removed the events into which this project could have been placed, required that any interaction would have to be online, and made the organisation of the project much more complex for the teachers. This led to the first planned session falling through, which limited the time to gather follow-up data from the completed session. The online format prevented observation of students' non-verbal interactions and, anecdotally, feels far less informal than face-to-face sessions.

This project involved critically appraising my practice in a way that I had not done before. This highlighted issues with my approach, areas for improvement, and positive aspects that I am keen to develop. In particular, viewing my practice from a dialogic perspective showed that I need to encourage students to elaborate on ideas and provide them with space in which to fully explore their thoughts. This will influence how I conduct future programmes and highlights the importance of questioning one's own assumptions about their practice.

In hindsight, I would have liked to self-audit and develop my practice before the project began. The session was positively received, but I feel being more aware of my own interactions with students would have benefitted the discussion. Ideally, the project would have involved two sessions with students, to help build rapport, and left time for completing the questionnaire, as experience shows this to be the only reliable way to ensure they are completed. For those who are conducting similar enquiries, I would advise them to ensure they are allowing students to fully explore and explain their ideas, particularly through asking them to clarify their thinking, and to do what they can to ensure every student is contributing, especially as is it easy to miss quiet students through an audio-only online call.

Next steps

This project suggests that Physics students in many of the demographics targeted by our Outreach activities view a more dialogic approach positively and felt it allowed them to better understand the topics discussed. To develop this, a larger number of students will take part in similar sessions, and feedback will be taken to determine whether this is more generally true. My intention is to develop greater teacher input, with the aim of teachers then continuing elements of this practice in their own Physics lessons. This ties with increasing focus on teachers in other Outreach programmes.

The initial inquiry question will still be addressed, as eight students is too small a number to make any general claims, but will be augmented with lessons learned from this project. This will focus on how high-attaining Physics students who feel uncomfortable engaging can be made more comfortable and whether this is predominantly an issue for female students, as other research suggests. Students' comments on the impact of language in the classroom, and how this contrasts with how they would like to express themselves, seems incredibly important and will be considered in the development of future events. To help address this, emphasis will be placed on the practice of those leading the discussion, whether it is myself or teachers, as this is key to ensuring students have the space and time required to fully explore their ideas.

References

BERA. (2018). Ethical Guidelines for Educational Research, fourth edition (2018). British Educational Research Association. https://www.bera.ac.uk/publication/ethical-guidelines-for-educational-research-2018-online

Cambridge Admissions Office. (2019, August). University of Cambridge Access and Participation Plan with the Office for Students 2019/20. https://www.undergraduate.study.cam.ac.uk/files/publications/university_of_cambridge_app_2019_20.pdf

Coultas, V. (2015). Revisiting Debates on Oracy: Classroom Talk – Moving Towards a Democratic Pedagogy? Changing English, 22(1), 72–86. https://doi.org/10.1080/1358684X.2014.992205

Davies, M., & Meissel, K. (2015). The use of Quality Talk to increase critical analytical speaking and writing of students in three secondary schools. British Educational Research Journal, 42. https://doi.org/10.1002/berj.3210

Institute of Physics. (2020). Limit Less: Support young people to change the world (p. 38). https://www.iop.org/sites/default/files/2020-11/IOP-Limit-Less-report-2020-Nov.pdf

Isaac Physics. (n.d.). Isaac Physics. Retrieved 22 December 2020, from https://isaacphysics.org/about

Mercer, N., Hennessy, S., & Warwick, P. (2019). Dialogue, thinking together and digital technology in the classroom: Some educational implications of a continuing line of inquiry. International Journal of Educational Research, 97, 187–199. https://doi.org/10.1016/j.ijer.2017.08.007

Mujtaba, T., & Reiss, M. J. (2016). "I Fall Asleep in Class … But Physics Is Fascinating": The Use of Large-Scale Longitudinal Data to Explore the Educational Experiences of Aspiring Girls in Mathematics and Physics. Canadian Journal of Science, Mathematics and Technology Education, 16(4), 313–330. https://doi.org/10.1080/14926156.2016.1235743

Office for Students. (2019, September 25). Search by postcode—Office for Students. https://www.officeforstudents.org.uk/data-and-analysis/young-participation-by-area/search-by-postcode/

Vrikki, M., Kershner, R., Calcagni, E., Hennessy, S., Lee, L., Hernández, F., Estrada, N., & Ahmed, F. (2019). The teacher scheme for educational dialogue analysis (T-SEDA): Developing a research-based observation tool for supporting teacher inquiry into pupils' participation in classroom dialogue. International Journal of Research & Method in Education, 42(2), 185– 203. https://doi.org/10.1080/1743727X.2018.1467890

Camtree

Camtree: the Cambridge Teacher Research Exchange Camtree is a global platform for close-to-practice research in education. Based at Hughes Hall, University of Cambridge, Camtree draws on high-quality research from around the world to support educators to reflect on their practice and carry out inquiries to improve learning in their own classrooms and organisations. The outcomes of these inquiries, once peer reviewed, can be published within the Camtree

Appendix A

Y11 Discussion Session – Dimensions (All times approximate)

00:00 – 00:05	**Introduction and overview of project aims** **Students introduction**
00:05 – 00:15	**Rules for dialogue**: Ask students for suggestions and agree ground rules for respectful debate
00:15 – 00:20	**Introduction activity: How would you measure the age of the sun?** Couple of minutes thinking time in pairs, then discuss benefits and issues with each idea
00:20 – 00:40	**Main discussion: What are some of the most fundamental units in Physics?** The idea here is to discuss which of the units they are familiar with can be broken down into more fundamental units (mass, length, time, etc.), and to introduce the idea of dimensional analysis using the units they have agreed on. If time allows, follow with an open-ended discussion around a physical definition for the direction of time.
00:40 – 00:50	**Students' Experiences**: A few questions on students' experiences of dialogue in the classroom, in Physics and other subjects, and their thoughts on it.
00:50 – Finish	**Physics and HE Q&A**: Any questions the students might have about university, studying Physics, Cambridge, etc