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RESEARCH REPORT

"I like knowing how it all fits together": Creating desirable difficulties in the Physics lab.

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Abstract

Background and purpose: To achieve in the classroom and to embed understanding students need to undergo a degree of struggle in the learning process. This paper explores changes to teaching techniques to ensure supported and appropriate levels of struggle takes place in all students in the Physics Classroom.

Aims: To explore how a change of technique in planning and teaching can lead to a shift in attitude in students, encouraging them to take greater risks with their learning and lead to possibly greater achievement

Study design or methodology: 50 students of mixed ability were taught a Physics topic, over a 6-week period using planning techniques that encouraged greater independence from the students.

Findings: Quantitative data showed slight improvement in test-based data. Observation from colleagues and from students showed a shift in attitude toward independence and further pursuit of mastery. Greater ownership encourages students to be more self-reliant whilst learning.

Implications for practice: Planning sequences of learning should be based around skills acquired rather than content. Undergoing research / deliberate practice enables teachers to refine their craft. Student independence and struggle can help students feel more confident in their learning approach.

Keywords: physics; desirable difficulties; independent learning; deliberate practice

Context

There are no answers in teaching that can make you successful. No list that you can check off and be "finished and perfect". To be a good teacher, you must strive to understand learning and keep this at the forefront of what you do.

This research project, carried out as part of an Institute of Education (IoE) Practitioner Inquiry programme, focuses on the Zone of Proximal Development (ZPD), an idea developed by the Russian Psychologist Lev Vygotsky in his sociocultural theory of learning:

The IoE Practitioner Inquiry programme was run with 12 teachers in my school completing different research studies. We were supported with an introduction into research and then with meetings to support progress.

On the one hand, when learning is too easy, students get bored and their attention drifts away from a lesson. On the other hand, if learning is too hard, then anxiety and confusion can result and when discouraged enough, students can develop a sense of learned helplessness. The "sweet spot" is the ZPD where students are challenged enough to maintain attention and they are able to learn new concepts with guided assistance and scaffolding. Then, as learning happens, the support structure is slowly pulled away. Eventually, students engage in independent learning and practice. (Warren, 2016)

My study examined how to create a ZPD in a highly academic setting, within an independent girls' school, with students studying in their first year of iGCSE Physics. This report provides an overview of my research study and findings but is also a narrative on the process.

Introduction

Where did my project start? With a sense of frustration – a feeling that I did not like the way my teaching was going. I was getting swept up in pleasing my students while covering/teaching the subject. I was frustrated by continuously feeding back on the same principles to the same students – not tackling problems but just identifying them. "Read the full question" (RTFQ) was constantly written on my students' work, and my students were constantly asking for guidance. In the busy world of a full timetable and the demands of being a Head of Department, I had become guilty of stealing:

Until we make the high level most challenging demands on our students we will never know whether they would have been capable of reaching the highest standards. Some aspects of our teaching actually make it less likely that students are able to demonstrate what they are really able to do or are exposed to how little they actually know. By scaffolding the work too clearly and for too long, we steal the struggle from them. This way we can undermine expectations and restrict the ranges of response that our students could potentially develop unaided and off the leash. (Warwick, 2015)

This links with Bjork and Bjork's idea that teachers can enhance the learning of their students by having them experience 'desirable difficulties' (Bjork & Bjork, 2011).

Research questions

What factors should be considered in creating a proximal learning zone? Students need support in the presence of someone they trust who possesses the skills and knowledge to guide them through the learning. Activities need to be created with the correct amount of scaffolding and social interactions need to take place to increase the student's confidence in their ability to attempt and tackle problems such as applications of concepts to unknown scenarios.

My research started with two Year 10 physics classes of "mixed ability", each containing 25 students. I examined a range of data sources alongside my knowledge of my students, to identify aspects of the curriculum that would create struggle. This was then used to develop tasks, with and without scaffolding, to encourage my students to take greater ownership over their own learning. The same interventions were carried out with each class over a period of 6 weeks, two times a week. The classes were seen on different days and different times of the day.

As a result of this process, I chose a module of the Physics curriculum to focus on, examined the content of a module, identified what skills it involved, mapped where the students had achieved similar learning goals previously, and planned activities that emphasise their skill level to the students. I re-designed the lesson plans to centre around "hinge points" (Wiliam, 2011), focusing on a key concept rather than covering content. Hinge points were setting open questions that really delved into the students understanding of the concept and getting them to answer and explain why they thought this was by providing written explanations/diagrams/mathematical workings.

Mid-term planning using hinge points then enabled me to identify, for each student, where the learning was secure, where it was less so, and to assign independent tasks to students. This process was completed in pairs with another Physics teacher to provide a supportive yet critical approach and to help increase the sources and types of resources provided.

Methodology

The tools I used for measuring the success of the study were as follows:

Student attainment (unit tests)

(1) Previous topic test data was compared to post study topic test data in terms of class medians. (Both topic tests contain a similar mix of questions – albeit on differing material, had the same total mark and were completed over the same time period – 40marks, 45 minutes)

(2) Standard deviation of marks on each topic test pre and post study was also examined.

Student interviews (group and individual)

(1) Students were contacted via email and interviews arranged and recorded.

(2) Individual and Group interviews (up to 4 students) were recorded.

(3) Open questions were used to explore the students' thoughts on the teaching carried out during the topic.

Teacher observation (by peers, senior team, mentor)

(1) All observations were unprompted and would have happened as part of the year review rather than being targeted.

Personal reflections (attitude shift and approach to planning)

(1) This tool can only be observational. However, reflection and evaluation of process is one of the most valuable teacher tools in lesson planning.

Ethical considerations and relationships

(1) Ethic considerations were planned and discussed with both school leaders and Institute of Education advisor
(2) Students and Parents were made aware of the study and the support it had from the school
(3) No personal data wereused in the write up of the project and all interview recordings were destroyed post analysis.

Results and discussion

Quantitative

Prior to the intervention, the median test topic test score was 78%, and this rose to 82% after the intervention. Both topic tests contain a similar mix of questions – albeit on differing material, had the same total mark and were completed over the same time period – 40 marks, 45 minutes. The distribution of results also moved in a positive direction, with the standard deviation (a measure of spread) moving from 10.4 (pre) to 7.3 (post).

However, more data would be needed to determine whether this modest improvement in results can be attributed to the intervention, as there may have been external factors (e.g. the nature of the exam questions) that it was not possible to control.

On reflection, I feel it would have been more useful to monitor and track the number and type of questions asked by students during independent learning tasks. The adapted Bloom's taxonomy developed by Koufetta-Menicou and Scaife (2000) provides an excellent scaffold to tally up questions asked. Repeating this post-intervention would allow me to determine the extent to which the nature of the questions had shifted away from lower order checking towards higher order reasoning following the intervention.

Qualitative

Illustrative teacher observation comments:

> KB has a superb rapport with her class and her easy-going approach alongside an excellent knowledge of her students and each of their needs allowed the girls to feel confident working independently on the task set. They were all happy to work at their own pace and weren't reliant on checking in with KB after every question. When students did need thing clarifying, KB spoke to the whole class so that they too would benefit from clarification and drew examples on the board as well as using a visual props. (Peer to Peer Observation)

KJB allows students to take ownership of their learning. Even when they are asking a question she turns it back to them and asks smaller more manageable questions of them until they have reached the answer of the question they were initially asking. From the quiet way in which the girls were working either by themselves, or quietly discussing ideas with a partner meant that it was entirely clear that they had confidence in their own ability. (Observation by Senior Team: Academic Deputy)

Kate has been exploring proximal zones and using MIDYIS data via her IoE project. This has informed her lesson planning and teaching of science skills. This is particularly reflected in her use of turning points.in learning about moments. Students felt secure and framed their responses independently. Students were encouraged to think and reason answers out for themselves. By asking them questions in order to recap knowledge and understanding, they were able to draw the correct conclusions. (Observation: Director of STEM: Mentor)

These comments from peers come from 3 different observations over the 6 week period. Two were appraisal observations and the third colleague came to see students that she taught in a different environment (Peer to Peer – English teacher). The comments made me feel that my intervention strategy was a success – I was doing less and I was not repeating myself. Observers in the classroom observed an attitude shift in my students that they did not see in these students in other. My students have an increased understanding of tasks and they are more willing to take risks in their application of learning. They could see the students struggling with material but rather than give up they were in a supportive environment with lots of resources that they could pull on to try to solve their own issues.

Illustrative student comments:

"I like my Physics lessons; they are funny but I work hard to understand the learning – everyone just gets on with it a bit more than we normally would on a Wednesday afternoon lesson."

"I've noticed a change in the way I do things in Physics and am happier to try by myself."

"When you (KB) first started doing this I didn't like it, it's much harder than it used to be but in a weird way it's much easier."

"I like knowing how it all fits together – that's important to me – I don't like being behind. It would be quicker if we just made notes and I would probably be happier. But this way I see how it fits together so we go much quicker than some classes on some bits."

"I don't randomly ask as much as used to, as I know I'll get that look."

These comments came from group interviews. Group interviews had a higher amount of comments and I felt these gave more honest feedback. Individual interviews were discarded as my open questioning technique was not up to scratch, but this was a great way to practice my data collection. There is true honesty from the students, and I took their meaning to be the following: Whilst the process was harder, in the end the learning made great sense and was much easier to retain. Proximal zone development increases student ownership of learning and makes them more self-reliant. Student reflections that they are aware of a change were also useful evidence to show the intervention had effect.

Conclusions

It is crucial that teachers understand just how important it is for students to struggle. Without some struggle, students won't learn material as well as they could. Without some struggle, students won't develop the growth mindset habits championed by Art Costa and Carol Dweck. Students need to be given the invitation to grow in terms of knowledge base and skill set. This can only happen if we "up" the challenge level in the lessons we teach them.

Struggle, however, must be effective. Students need to experience the thrill of achieving a difficult goal and must feel encouraged to realise that this is its own reward. There needs to be an established relationship where the students trust the teacher and are not anxious about the covering of content.

Creating a proximal zone required me to adapt the way I approached my planning. I now look more at skills rather than content when planning how to teach each concept. My use of medium-term planning has increased and so has the importance of mapping with students, so they feel secure in how their learning is progressing.

Key outcomes and project impact

(1) Proximal zone development increases student ownership of learning and makes them more self-reliant (student comments).
(2) My students have an increased understanding of tasks and they are more willing to take risks in their application of learning. I put this down to a higher level of confidence in their initial skill level (colleague observation).
(3) Planning around skill rather than content has made me more effective in task selection and increased my use of effective questions in the classroom (personal reflection).
(4) Creating a ZPD requires trust. Students need a greater sense of progression and greater insight into of our teaching intentions if they are to undertake struggle (personal reflection).

Evaluation

To revisit my introduction: I started with a frustration – a feeling that I didn't like the way my pedagogy was going. The IOE process made me verbalise what I didn't like – it gave me the opportunity to separate my whines into goals and what I wanted a solution to look like. Being

able to undertake a deliberate practice project like this, with support in school, or as part of a larger qualification; Chartered college of teaching is a wonderful opportunity to delve into your practice and shine the light on areas you would like to change. The journey of self-reflection is a powerful tool.

Have I achieved the solution to all my teaching issues? No – this is impossible. To be an effective teacher you must keep learning and keep struggling. Do I feel like I am on a better path? Definitely - 100%.

The support from the IoE has encouraged me to explore research into education and learning. I have increased my day-to-day exposure to teaching strategies and I am much more effective and happier in my approach. As part of the project we all shared our findings with the wider school. I have also shared the results outside my setting and led INSET in a number of similar science departments on how to encourage greater independence in students. I would recommend involvement in the process of undergoing teacher research/deliberate practice to anyone and everyone.

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