DEVELOPING FLEXIBLE APPROACHES TO PROBLEM-SOLVING THROUGH ROLE-PLAY WITH UPPER SIXTH BOYS

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Abstract

Teaching in an academically-selective boys' school gives ample opportunity to teach boys who are exceptional at the subject of physics. Many are hoping to attend the best universities in the country to study either physics or engineering. A frequent hardship for them is adapting their academic and examination abilities into a meaningful demonstration of their prowess during a university interview, often costing them their place. Through this action research project, a group of Sixth Form boys underwent a series of subject and content relevant role-play activities, which enabled them to identify their own weaknesses within interviews and improve their confidence to adapt their subject knowledge to an applicable situation. The project was a success at assisting students to be flexible within their interviews for Oxford and Cambridge Universities. Through completing this project I will be adapting my own teaching practice in the future to include similar activities in all lessons I have with high-attaining Sixth Form boys.

Introduction

Research Question: *How might role-play within physics lessons develop a more flexible approach to problem solving in Sixth Form boys?*

Whilst teaching at an academically selective all-boys' school in Britain, I am often teaching young men who, throughout their school careers, have matured into fantastic physicists who have both a strong understanding of physics concepts and also the mathematical prowess to be able to tackle problems. Many of these students then go to apply for physics, engineering, and STEM courses at university. During the interviews for these courses, they are given a mathematical or physics problem to solve live for the interviewer while talking through their reasoning and how they reached the answer. Many of our boys who are able

to perform exceptionally in examinations, however, find it terribly hard to translate their expertise into an interview context of questioning and answering.

Through this research project, I hoped to improve the adaptability of my students; to enable them to be more flexible in how they answer questions, rather than just solving the conventional examination-style question. I hoped that my action would enable them to access live problem-solving skills and perform under interview pressure. The boys needed to be able to adapt their academic prowess and ability in exams into an interview environment.

To improve their confidence for university interviews, I used verbal answering within the classroom and then role-play between students. Throughout the process, we still covered course content applicable for their A-Level examinations in anticipation that some boys may disengage with this if they were not applying for a STEM course at university. The hope was that all boys would buy into the process, regardless of the course for which they would be applying.

I tried two different activities which were repeated and adapted, to find ways in which to improve the confidence of my students. Throughout this, the boys used various methods to give me feedback on how they were finding the activities and their impact. Action research was an appropriate methodology as it allowed me to immediately discover how and why the students were responding to the activities, how the activities should be changed, and how the impactof my action could be maximised.

Literature Review

Since the early 1950s, researchers have been drawing a link between students' creativity and adaptability, and their academic and professional success (Bronson & Merry, 2010). Through his use of a creativity test, Torrance (1972) sought to quantify flexibility within students (by students answering a set question, and then finding another possible answer, and then another, demonstrating their ability to give novel answers) and linked this to later life success (judged by the number of companies started and patents submitted). Torrance found a direct correlation between childhood creativity, flexibility, adaptability, and professional success. Millar (2010) has since been tracking these creativity scores and found decreasing scores and a decreasing ability in students for outside-of-the-box thinking.

Bringing this into the 21st century, Martin, Nejad, Colmar and Liem (2013) have been running studies assessing the adaptability of high school students and comparing this to both their academic success and their mental health state. Martin et al. performed a study on nearly a thousand students to find the importance of adaptability within students in the classroom. They defined the more adaptable students in their study as those who were more skilled at a series of novel tasks dissimilar from those in the ordinary classroom. The mental health data were collected through two questionnaires which were loaded with scales for the students to rate their opinions of themselves and their enjoyment of life. The study found that more adaptable students had greater academic success and more life satisfaction. These reasons alone are clear indicators that we as teachers must encourage students to be flexible within the classroom, and that the decrease in creativity, flexibility, and adaptability is a serious concern.

Scherer (2015) notes that many researchers agree that adaptability is an important characteristic for students in the 21st century. Scherer comments on the struggle of researchers to truly assess the adaptability of participants in their studies, and to be able to quantify an improvement in adaptability. Like Martin et al., (2013), Scherer sees the only true way to assess adaptability is through the introduction of novel activities within lessons. Scherer uses computer-based complex problem-solving activities, but recognises that success at these could be attributed to participant intelligence rather than adaptability.

According to Scherer, a participant's adaptability can be evaluated comprehensively by first being presented with a problem that they solve successfully, and then being given a second problem that may seem equally difficult, but that actually requires a different set of skills to solve. Scherer then recorded the time it took each participant to complete the new activity and determined the level of adaptability demonstrated by that participant. Improvement in adaptability is demonstrated when a participant answers the second set of questions within a shorter period of time. I liked this judgement of adaptability and means of assessing an improvement and decided to incorporate the strategy into my investigation by having the students complete problems which looked like previously-seen ones, but required a different concept in physics to solve.

The need for adaptability is undeniable, but how can teachers nurture adaptability within our students? Both Scherer (2015) and Martin et al., (2013) describe adaptable students as those who can comfortably handle novel learning environments. Students therefore need practice and experience with these novel environments.

Students within physics classrooms typically demonstrate their mastery of a task by writing down the answers to a set of questions and the teacher marking them in red pen and giving written feedback. Cooper, Erling, Mutlow, Lee, Stutchbury, Wolfenden, and Paranjpe (2015) in their paper, *Talk for Learning*, highlight the benefits and importance of talk within the classroom. They note, students who regularly talk through their understanding with teachers and peers have far superior reasoning skills and their awareness of learnt topics is far more organised. Therefore, Cooper et al. encourage teachers to allow for classrooms where students are discussing the material more actively. To assist less communicatively-confident students, the teacher should model answering clearly, methodically, and concisely. Teachers should also teach and model ways of encouraging a speaker to give more information. Questions such as "Why?" and "Can you see any problems with that solution?" are easy ways for students to assist and encourage their peers to talk more. Students are then paired and one will answer a question and the second will use the skills learnt to enable the first to divulge more and more of their understanding, or return to the start and try their description in another more ordered manner. This strategy is backed up by Smit (2008) who says, "the ways of using language are the ways of thinking." He believes the learning process is far more closely-knit to active dialogue between students than it is to reading or writing. Hence, I employed these talking-and-learning activities in my action research project in the hope that it would create a more novel learning environment and foster an adaptable nature in the boys.

The HEADSS Research Project (Cahill & Coffrey, 2013) was a learning activity developed for student doctors in Australia and around the world. Each student doctor was paired with a high school student. The high school student was then given a profile of a patient and the symptoms the patient was exhibiting. During a role-play activity, the student doctor carried out a medical consultation with his or her patient and followed an uncomfortable line of questioning to properly diagnose the teenager. Following the role-play consultation, both the student doctor and the high school student provided feedback to one another on how

the consultation made them feel, how easy they were to communicate with, and what improvements each could make. The researchers found that the student doctors became more confident at approaching topics of a sexual or taboo nature with young people. Crucially, the student doctors were more able to adapt their academic healthcare knowledge to realistic workplace scenarios, enabling them to ask the questions which were pertinent to each unique situation. The teenagers, through taking on the persona of another, found increased social competency, understanding of how others perceive them and, most importantly, could better interpret how they were presenting themselves to another person.

Cahill and Coffrey's (2013) project laid a fantastic grounding for the action in my project, with students taking part in role-play interviews and then being able to recognise how their own behaviour would be experienced by others. The pinnacle would be if the role-plays the students carried out enabled them to adapt their classroom skills to novel scenarios.

Research Context

Dulwich College for boys was established in South London in 1619 by Edward Alleyn, a contemporary, colleague, and peer of Shakespeare. It sits in the affluent area of Dulwich, which is also bordered by council properties and poorer neighbourhoods. It is now widely considered to have one of the most diverse school populations of any private school in Britain. With a plethora of sports and academic scholarships enabling students from any background to attend, a generous bursary system, and a boarding community with students from around the world, the classrooms at Dulwich College are exceptionally cosmopolitan.

Most, but not all, boys are attracted to the school primarily for its sport and sporting ethos, and secondarily by the reputation of Science at the school. Most students will study Science and Mathematics at A-level.

The participants for this action research project were ten boys in one of my Sixth Form groups (final year before leaving for university). Aged 17 and 18 years, they were a particularly appropriate group as nine of the ten boys were applying for Oxford or Cambridge University and I hoped to enhance their chances of success as much as possible. I also saw this group three times every week and they were very open to trying new learning experiences, making them ideal for my project.

All students gave their permission to take part in the research and permission was also given by their parent/guardian to the Boarding House Master. The students' names were altered to protect their identities in the reporting of the project's findings.

The Action

The system below was what I originally planned to follow and was appropriate for the first iteration of the action research. I employed this within my lessons over a period of 10 - 12 weeks.

1. Answer to extended response questions verbally within lessons
    a. Modelling
    b. Attempt
    c. Peer assessment
2. Role-play university interview
    a. Interviewer chooses question from list
    b. Interviewee attempts the questions
    c. Interviewer offers support
    d. Each give feedback on how well the other performed

1. Answer to extended response questions verbally within lessons

Within lessons, once students had learnt content and used the Assessment for Learning to ensure they understood it, students answered written questions with pen and paper, which I then marked. This was my standard, conventional style of running all lessons.

Once a week, when appropriate, I altered the above strategy to include verbal answering. Students first described a physics process to a partner using notes and the partner gave feedback on the clarity of the description or helped them produce their answer if support was needed. Following this, the student verbally answered an extended writing examination question to their partner. The partner gave them a mark out of 6 using the official mark scheme and then again critiqued them on their clarity and ease to follow (performance).

We repeated this process, once a week, over four to six weeks, hopefully building the boys' confidence in answering questions verbally. I allowed this to constitute around 30 minutes of their hour-long lesson.

2. Role-play university interview

The second stage of the action involved incorporating university interview role-plays into my lessons. I began by modelling some aspects of a good interview, including demonstrating and discussing the importance of beginning with a good handshake, being polite and interested, then how to answer questions, allowing time to think, using diagrams to aid one's explanation and appropriate ways of asking for help.

After this introduction, the boys were put into pairs to do their own role-play, with one student being the interviewer and the other interviewee. The interviewer chose a question from a list of known interview questions (solutions are available to the interviewer) and the interviewees answered the question verbally, using diagrams and equations if necessary, talking through their thought process and reasoning. The interviewees were allowed to ask for help or concede that they could not finish it, at which point the interviewer would try to give prompts. To finish, the interviewer gave feedback, primarily about the clarity of the answer, and how easy it was to follow the answer. Secondarily, the feedback focussed on whether the answer was correct; for this activity, however, I saw this as less of an important outcome.

The role-plays were repeated, once a week, over a five-week period, giving each student several chances to experience each role. Again this constituted around 30 minutes of one of their hour-long lessons.

Data Collection

Once the nature of the research has been laid out to the boys, my data collection began. The boys completed an entrance questionnaire to gauge their feelings of preparedness and confidence levels for the university interviews. As well, the questionnaire sought to uncover their anxieties and understand the boys' awareness of the interview process. The questionnaire contained a mixture of scale-based questions as well as written responses to questions that sought to understand their confidence in their own abilities. I gave this same questionnaire again at the end of the process, so I could conduct analysis and a comparison.

Once the qualitative data had been collected in the above questionnaire, I combined this with a quantitative assessment. Each student received one or two mock interviews from the physics department. The interviewers noted the students' confidence. I asked the department to give a formal grade for each boy's confidence, clarity of explanation, and completeness of answers. Each of these were graded on a scale from one to four. Interviews were conducted by pairs of teachers in order to mitigate subjectiveness by any one teacher. This ultimately gave me quality quantitative data on each boy's preparedness.

All the research activities happened in my own classroom during lesson time. Owing to this, I decided that I would be in a prime position to make structured and unstructured observations. I ensured I was circling the room whilst the boys were carrying out the role-play activities, and made notes on the conversations and feedback I saw happening. I was watching and listening to the quality of the answers given by students, and also the quality of the feedback and direction given by the partners in each role-play. This had the benefit of observing the students in real situations. During this, I recorded notable statements made and how the boys reviewed one another's performances. To aid with this, I also video-recorded some of the sessions, directing the video and mic to a different group each time.

I also sought regular feedback through conversations with specific boys to find how they were finding the relevance of the activities. The conversations supplied me with qualitative data on how the boys were finding the experience. I judged, from the conversations the boys were having with one another and with myself, if and how the activities should be adapted from week to week to maximise their impact.

Data Analysis

Once I had collected all the data, I had to work with them to garner some tangible meaning. The entrance and exit questionnaires had two main styles of questions, the first of which were answered on a sliding scale (scored between 1 to 4). I found the means of these and compared these from entrance to exit. I also found the average gain or loss of scales. I was looking for trends of improvement or depreciation. More powerful in the questionnaires, were the written answers, which I analysed for themes across the answers in both the entrance and exit questionnaires.

The notes from my observations and the recordings of interviews I subsequently watched back and focused on collecting snippets of the feedback given to the boys by one another. I kept the pieces of feedback in chronological order, so I could examine how the ability and understanding of what a successful interview appeared to be evolved during the course of the activities.

Discussion of Results

The first point of data collection for me were the entrance questionnaires. The recurrent theme in my analysis of the responses to this first questionnaire was that the boys were especially confident about their own abilities and how well they could answer questions. The obvious concern amongst the boys was about how well they had genuinely prepared themselves for the interview process. The boys also were given the opportunity to record their worries for the interviews. Here, six of the ten boys spoke of being worried about how they would be able to communicate their knowledge. Anthony said, “I am very passionate at what I'm talking about, if I know the topic. I can often go down the wrong path or think with the wrong things in mind when answering questions.” James said, "I have a good understanding of the advanced physics and maths knowledge but I find it hard to “think out loud.” This was the feedback I was expecting and hoping for, showing that they were confident in their abilities, but concerned about their flexibility in methods of problem solving, and in adapting their knowledge to interview scenarios. I was very pleased to see that the boys shared my concerns.

Following this, I moved into performing the first part of the activities, with the boys in pairs, one answering the questions and the second with a marking scheme. The process really hit a snag here when all the boys struggled to give meaningful feedback to one another. From the video recordings of the sessions I made, the feedback was hugely limited to statements along the lines of “Yeah, that was great,” or “It was hard to know what you were talking about” and, "You got the answer wrong." Although at this stage it was providing useful practice to my students, nothing was materialising as constructive criticism.

It quickly became apparent to me that the boys had little to no experience of giving qualitative feedback to peers. To remedy this, I did two things. Firstly, I spent one session modelling feedback and doing group feedback. To do this, as a class we watched one boy

verbally answer a question and then all boys had to give a unique bit of feedback and I gave an extended piece. This gave all the boys an experience of a plethora of mechanisms and styles for feedback. Secondly, I gave the interviewer a framework to rate the interviewee. They scored the interview from one to four on clarity, confidence, completeness of answer, and number of prompts needed. This gave the interviewer a guide to what aspects of the answer they could deem to be good and bad.

Following these changes, the feedback the boys gave began to become far richer. Amongst the recorded feedback was, "despite you getting the right answer you didn't include me in your thought process" and, "try listening out for the hints I'm giving, anything I say is leading you towards the answer." This framework really allowed the richness of the feedback to improve within the boys, signalling how and why habits were good or bad, and what looked impressive to the interviewer.

I recorded the marks the boys had given to one another and hoped to be able to see progress in marks. Upon analysing the marks for clarity, confidence, completeness and prompts, I found no striking patterns of progress. I did not mind this at all as the marks were not really designed to be used as a quantitative marking system. They were far more useful in enabling the boys to be able to give valuable qualitative feedback to one another through using the marks to recognise others strengths.

At the end of the activities, I followed it up with an exit questionnaire. The most interesting thing from this was that only three of the ten boys believed their confidence at answering interview questions had improved, whilst two of the ten boys rated their confidence lower than when they started. The rest rated it the same. Of the three whom said that their confidence had increased, Chris stated, "The activities gave me an opportunity to rehearse how I was going to approach the questions, and gave me a chance to do this over and over again." The responses from the two of the ten boys who lost confidence were incredibly interesting. This indicated that through the completion of the activities, the students had a far greater understanding of their own abilities and how they compared to others from completing the process. Most importantly they had a far superior understanding of how they appeared to others. Most of the boys ranked that their ability at solving the interview style questions was outstanding and nine of the ten considered themselves to be more

prepared for interviews than when they started. This combination of lower confidence but greater preparedness showed how much the activities enlightened the students for the task ahead. All of the ten boys rated that the activities had been *Outstanding* or *Very Good* in supporting their application to university. These results showed conclusively that the openness to flexibility supported the boys in the role-play activities; they were now able to adapt their academic learning and success from lessons and examinations into presenting themselves in interviews scenarios.

The boys were able to give their final comments too within this questionnaire. Within these were the comments I most expected such as, “I most enjoyed the problem solving which was different from the normal exam questions in lessons” and, “I loved how hard the questions were and puzzling through them.” The experiences the boys had were focused on the practice they had of being in an interview environment. Far more common, however, were comments based on the experience of being the interviewer. These included, Anthony saying, “The best part was seeing how enthusiastic Will was talking about mathematics. I would never have spoken like that in an interview.” James added, “Seeing Eddie talking, really showed me how I should be answering the questions.” Waldo’s comment, “It's quite meaningful to do the interview as an interviewer as you can understand what the interviewer is looking for during the process." I adored these comments, as they demonstrated the value of boys being on both sides of the table and how both of the experiences were so valuable in preparing for the interview. Through witnessing others, the boys were able to incorporate their observations into their own practice and become more flexible in how they solved problems.

The final pieces of data were the conversations I held with the other physics teachers at my school. Each Oxbridge applicant is given a single mock interview by a member of the physics department at Dulwich College. Following these, each time a boy from my study had a mock interview I held an audio recorded conversation with the teacher. These were of varying quality to me in terms of usefulness. The theme of these was that the boys who were interviewed before my activities were weak on enthusiasm: “James was weak and seemed grossly underprepared. Even when he told us the parts of physics he was interested in he couldn’t tell me any more about it.” This stood in vast contrast with the feedback for Eddie who was interviewed after my activities: “He was calm, confident and engaged, articulated

his thoughts really well and seemed on top of all the material we were asking about. He did a good job of approaching the questions in a logical manner. The only criticism would be that I would have liked him to seem a bit more excited when I asked him to explain lift." Although anecdotal, I think this shows the preparation and adaptability for new experiences the activities have given the boys. It is worth adding that James was subsequently offered a place at Oxford.

Overall, the qualitative data showed an obvious improvement in the flexibility of the boys I taught, which allowed them to answer questions in a fashion they were previously unexperienced in. Both sides of the activities were key to enabling the boys to adapt the skills they already had. The experience of sitting the interviews gave them the experience needed and giving feedback gave them the opportunity to see best practice and adapt their own approach. This is nicely summed up by Ian, who, in the entrance questionnaire, described himself as *Careful and Eager,* and in the exit as *Prepared and Experienced.* He commented, "The best part of the activities was allowing me to become more confident in talking about physics."

Conclusions

Through completing this action research, I developed a sound way to improve the confidence of the boys I teach to adapt their subject knowledge into interview scenarios. There were two strong learning opportunities within my activities to support the boys. Firstly, the opportunity to sit and practice answering questions. Familiarity and rehearsal supported the boys' confidence with this. Secondly, the mechanism of observing and judging an interview from the other side of the table. This allowed the boys to identify strong and weak behaviour and recognise how they could alter their own practice.

I will definitely include these activities whenever teaching high-attaining Sixth Form groups with a large number of students who are hoping to apply for physics and engineering degrees. I hope to gradually titivate the activities to include harder questions, yet which are still accessible to the student interviewer.

For the next stage of my research I will be moving to a coeducational school. I will be completing similar or identical activities with mixed gender pairings. I hope to see how this

may boost the confidence of girls applying for STEM subjects, or whether it would be beneficial for boys and girls to stay in single-sex pairing.

Reflection Statement

For myself, the most exciting part of this project was seeing just how much the boys engaged with the material. The idea of taking part in a research project was very motivating for them and they were all proud that I had selected their class.

After six years of teaching, I have a very formulaic method of teaching and have proven systems in place. Completing this action research project has given me a safe space to delve beyond the curriculum and examination preparation to test new methods of imparting knowledge to my students and, most importantly, preparing them for the outside world.

The iterative nature of the action research was the most useful part of the model for me and my project as it enabled me quickly to adapt and improve so that the learning experience was as beneficial to the students as it could be.

I aim to continue this action research in a less formal manner over the coming years.

References

Bronson, P. & Merryman A. (2010, July 10). The creativity crisis. *Newsweek*. Retrieved from http://www.newsweek.com/creativity-crisis-74665

Cahill, H. & Coffrey J. (2013, November). Learning Partnerships: Re-figuring the possibility of communication between young people and their doctors and teachers. University of Melbourne. https://tasa.org.au/wp-content/uploads/2013/11/Cahill.pdf

Cooper, D., Erling B., Mutlow J., Lee C., Stutchbury K., Wolfenden F. & Paranjpe S. (2015). Talk for learning [Pamphlet]. TESS-India. http://www.open.edu/openlearncreate/pluginfile.php/135222/mod_resource/content/1/KR03_PDF.pdf

Martin, A. J., Nejad, H. G., Colmar, S., & Liem, G. A. D. (2013). Adaptability: How students' responses to uncertainty and novelty predict their academic and non-academic outcomes. *Journal of Educational Psychology. 105*(3), 728-746. http://dx.doi.org/10.1037/a0032794

Millar, G. W. (2010). *The power of creativity* . STS Testing.

Scherer, R. (2015). Is it time for a new measurement approach? A closer look at the assessment of cognitive adaptability in complex problem solving. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2015.01664

Smit, M. (Presenter). (2008, November). *Talk for learning*. Speech presented at NaPTEC, North Yorkshire, UK. https://www.naptec.org.uk/s/Mike-Smit.pdf

Torrance, E. P. (1972). *Teaching for creativity*. University of Georgia. http://cpsb.com/cru/research/articles/TeachingforCreaTorrance.pdf

Appendices

Entrance Questionnaire	https://goo.gl/NNxVmy
Exit Questionnaire	https://goo.gl/SUfDLc
Responses	https://goo.gl/4sc7ef

Sample of interview questions with solutions as used by the interviewers are overleaf:

Complete collection can be found at https://goo.gl/Mi7DqM .

Interview Questions

Interviewer: *Interviewee:*

Fermi Question - How much water flows through Amazon river?

Consider the width and depth of the river along with the speed of the river.

Multiply all these together to get an answer.

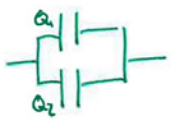
If we estimate the mouth of the river to be 2km wide and a depth of 100m and that it is flowing at a rate of 2m/s then the volume of water will be

$Volume = 2000 \times 100 \times 2$ (1)

$= 400,000\ m^3/s$ (2)

Clarity: Confidence: Completeness of Answer: Prompts:

Prove $C_{tot} = C_1 + C_2$



$Q_T = Q_1 + Q_2$

$Q = CV$

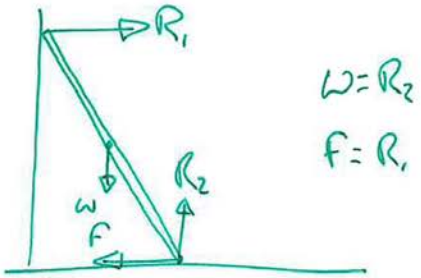
$C_T V_T = C_1 V_1 + C_2 V_2$

Parallel, so V same on each plate, so V cancels

$C_T = C_1 + C_2$

Clarity: Confidence: Completeness of Answer: Prompts:

Draw a free body diagram for a ladder leaning against a smooth wall. Label which forces are equal.

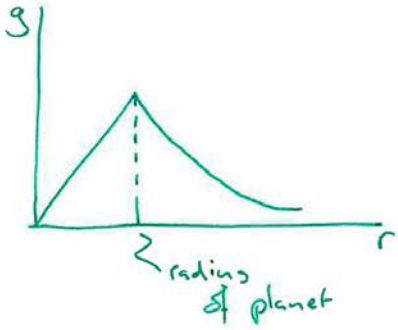


$W = R_2$

$F = R_1$

Clarity: Confidence: Completeness of Answer: Prompts:

Draw of a graph of the gravitational field strength against the distance from the centre of the planet.



Find the equation which describes each part.

(1) $g = \frac{GM}{r^2}$ $M = \rho V$ $V = \frac{4}{3}\pi r^3$

$g = \frac{G\rho \frac{4}{3}\pi r^3}{r^2}$

$g = G\rho \frac{4}{3}\pi r$ $\therefore$ $g \propto r$

straight line/through origin

(2) $g = \frac{GM}{r^2}$

Clarity: Confidence: Completeness of Answer: Prompts: