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**WHAT IMPACT DOES TARGETED PROMOTION OF STEM OPPORTUNITIES HAVE ON PUPILS’ ATTITUDE TO STEM?**

**BY**

**2331083G**

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**ABSTRACT**

STEM is an integral part of our world from how we live our lives to the jobs we work in, and the importance of STEM is only growing. STEM industries are the fastest growing in the world and it is a major focus of the Scottish Government to develop and build its STEM capabilities to continue to compete as a world leader in science and engineering. However, there are many perceived barriers to entering STEM. The inequity in STEM representation in gender, ethnicity and deprivation begins in early education and must be addressed. These barriers must be broken down through the development of robust educational programs to allow all young people to develop the necessary skills to take their place in the modern workforce and contribute to modern society

This study used a mixed methodology to understand the impact targeted STEM opportunities have on pupils’ attitudes towards STEM. This study used class and extracurricular project-based STEM learning to look at whether participation in STEM projects would change the way pupils view STEM and their future involvement in it. Questionnaires were used to gather quantitative and qualitative data both pre- and post-intervention. This was then analysed to identify any changes in the way pupils viewed who could work in STEM, STEM education, and STEM careers. Interviews were also carried out post-intervention to gain a more personal view of project-based learning and its impacts.

The study did not find that participation in targeted STEM opportunities had an impact on the attitudes pupils held towards STEM, it did show that working within a team on a project helped pupils develop skills in teamwork and communication. While this study did not have an impact on pupils’ attitudes towards STEM future studies may wish to revisit project-based learning over a longer period and with a larger cohort.

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**PERMISSION TO CONSULT**

The author gives permission for this dissertation to be made available to anyone who knows of its existence and wishes to consult it.

**ABBREVIATIONS**

|  |  |
| --- | --- |
| BERA | British Educational Research Association |
| BGE | Broad General Education |
| Big Data | Large amounts of data collected by companies to develop for the future. |
| DYW | Developing the Young Workforce |
| EBSOC | Easter Bush Science Outreach Centre |
| ETLW | Early Years Learning Framework (Australia) |
| GTCS | General Teaching Council for Scotland |
| Industrial Cadets | Industry led quality benchmark for education programs run through the Engineering Development Trust |
| iSTEM | Integrated Science, Technology, Engineering, and Mathematics |
| Liedos | Company which provides information technology solutions to customers around the world |
| NSF | National Science Foundation |
| PIL | Project-based Inquiry Learning |
| PLS | Plain Language Statement |
| RAiSE | Raising Aspirations in Science and Stem Education |
| SMET | Science, Mathematics, Engineering, Technology (Old acronym) |
| SSERC | Scottish Schools Education Research Centre |
| STEM | Science, Technology, Engineering, and Mathematics |
| THALES UK | Global technology company with a large focus on digital solutions |
| TRAIL | Teachers and Researchers Advancing Integrated Lessons in STEM |

**TABLE OF CONTENTS**

Abstract……………………………………………………………………………………………………………………………….iii

Acknowledgements……………………………………………………………………………………………………………..iv

Permission to Consult……………………………………………………………………………………………………………v

Abbreviations………………………………………………………………………………………………………………..…….vi

Table of Contents

Chapter 1: Introduction……………………………………………………………………………………………………….9

* 1. Background…………………………………………………………………………………………………..9
  2. Rationale and Research Questions………………………………………………………………10
  3. Dissertation Outline…………………….………………………………………………………………12

Chapter 2: Literature Review………………………………………………………………………………………………13

2.1 What is STEM? ……………………………………………………………………………………………13

2.2 What is the Importance of studying STEM?....................................................15

2.3 Barriers to Studying STEM……………………………………………………………………………17

2.4 How is policy influencing the delivery of STEM education?............................21

2.5 What strategies can be used to increase engagement in STEM?....................24

2.6 Conclusion…………………………………………………………………………………………………..27

Chapter 3: Methodology…………………………………………………………………………………………………….28

3.1 Introduction………………………………………………………………………………………………..28

3.2 Action Research…………………………………………………………………………………………..28

3.3 Mixed Methods Research……………………………………………………………………………29

3.4 Data Collection and Instrumentation…………………………………………………………..31

3.4.1 Questionnaires……………………………………………………………………………………….31

3.4.2 Interviews………………………………………………………………………………………………32

3.5 Validity and Reliability…………………………………………………………………………………34

3.6 Data Analysis……………………………………………………………………………………………….34

3.7 Ethical Considerations…………………………………………………………………………………36

3.8 Summary…………………………………………………………………………………………………….37

Chapter 4: Discussion of Findings…………………………………………………………………………………….38

4.1 Questionnaires…………………………………………………………………………………..……….38

4.2 Interviews……………………………………………………………………………………………………50

Chapter 5: Conclusions and Recommendations………………………………………………………………….53

5.1 Summary of Discussion and Findings…………………………………………………………..53

5.2 Key Findings………………………………………………………………………………………………..55

5.3 Limitations of the Study………………………………………………………………………………55

5.4 Evaluation of the Study……………………………………………………………………………….56

5.5 Conclusion…………………………………………………………………………………………………..57

5.6 Dissemination……..………………………………………………………………………………………58

5.7 Recommendations………………………………………………………………………………………58

Appendices…………………………………………………………………………………………………………………………60

Appendix A Questionnaire...……………………………………………………………………………….61

Appendix B Interview Schedule ………………………………………………………………………….68

Appendix C Plain Language Statements, Consent Forms and Privacy Notice……...69

Appendix D Project Overviews……………………………………………………………………………80

Appendix E Coding for Question 14……………………………………………………………………81

Reference List…………………………………………………………………………………………………………………….83

**Chapter 1: Introduction**

**1.1 Background**

STEM stands for Science, Technology, Engineering, and Maths. There are few who would not be able to tell you the importance these four disciplines have in the world. From the ability to check our change at the supermarket to the technology the vast majority carry around in our pockets, STEM is an integral part of our lives. However, despite these incredibly common examples of STEM being used daily by the public, they feel a disconnect towards it. They view STEM as something that may help them in their lives but not something that they are directly involved with and, perhaps a more worrying development, something that they have come to distrust and be suspicious of, especially the science aspect of STEM. This disconnect seems to begin very early on in school pupils who, despite having classes in three of these subjects, do not see how they can be involved in them in a greater way or view them as areas they could build careers in.

The basis of this research came from a focus on STEM education and careers at all levels involved in education, from government right down to within the science department in school.

The Scottish government published their paper on Science, Technology, Engineering, Mathematics – Education and Training Strategy for Scotland in October 2017 (Scottish Government, 2017a). This strategy laid out a detailed plan to embed STEM learning and engagement in our society to improve future career opportunities and increase the STEM capital of all so they can engage with the rapidly changing world around them. The main basis of this is in laying down suitable knowledge and abilities at the primary and Broad General Education (BGE) phases of education through high quality STEM learning in both formal and informal settings.

At a school level, the department has been looking at the fall in numbers of pupils selecting science during the senior phase of their school career. This is also impacting the number of pupils who will then choose science and STEM based university degrees and careers. There have been many discussions as to the root of the problem and what could be done to encourage pupils to continue their education in science and STEM. In line with the Scottish government policy and through personal professional responsibilities members of the department have been working to halt and reverse this fall in numbers. Different approaches have been implemented through innovation within the classroom and an increase in extracurricular program engagement to change the perceptions of science and STEM, but more needs to be done.

This study looks to build on and develop the approaches of the department while measuring the impact on attitudes amongst pupils to them.

**1.2 Rationale and Research Questions**

As we move into the future the number of jobs in STEM-based industries is only going to increase. We, as a world, are becoming increasingly reliant on digital technology and STEM-based solutions for everything from our health to simply making our lives easier. Going forward a steady and, ultimately, increasing supply of workers capable of working in these industries will be needed. That must start in our schools where pupils are encouraged to see the opportunities that studying STEM-linked subjects can bring them, along with providing them with the capabilities to make informed decisions in a STEM-based society.

While the issues facing STEM education have long been a focus of research, with many barriers to entering or continuing education and careers in STEM identified, there is far less information available on how to remedy this issue.

The aim of this research was to determine pupils’ views on STEM and if providing them with opportunities to participate in STEM-based projects out with the normal school curriculum would influence these views. Specific research aims were to:

* Find out the views and attitudes to STEM held by pupils
* Understand the barriers that the pupils feel exist for studying or working in STEM
* Understand the impact of participation in projects and whether this changes their views and attitudes to STEM

The overarching question to be answered is:

* What impact does targeted promotion of STEM opportunities have on pupils’ attitude to STEM?

To address this question three different STEM projects were identified that would be suitable for pupils to participate in, these included both class-based and extracurricular projects. The results were obtained through questionnaires and interviews which provided both quantitative and qualitative data.

This research may provide a strategy for STEM departments in schools to encourage a greater uptake of STEM subjects in the senior phase and encourage more pupils to consider STEM-based careers. It may also provide a new perspective on what would be considered effective STEM teaching and encourage change in the way the curriculum is delivered and in what context. It would be quite easy for teachers from any of the STEM subjects to be able to replicate this study to fit their own contexts through the choice of project used. The school, local authority and wider Scottish education establishment could all benefit through feedback, dissemination of results and the sharing of practice. This could help to address a major priority of the Scottish governments education policy and key focuses in the school and science department improvement plans.

The researcher, personally, will benefit from this study by gaining a greater understanding of the views and feeling of pupils; development of effective teaching strategies and an increased understanding of creative ways in which the curricular requirements can be delivered.

**1.3 Dissertation Outline**

This dissertation will be presented in five chapters.

Chapter One provides the background and context for the research. The rationale and research questions were presented, along with an outline of the dissertation.

Chapter Two provides an in-depth literature review to highlight the current understanding of the issues around STEM education including barriers to studying STEM and the importance of STEM.

Chapter Three will give details of the methodologies used in this research, why they were chosen, their advantages and their disadvantages. Data analysis, validity and reliability and ethical considerations are also covered.

Chapter Four will present and discuss the findings of the research.

Chapter Five will look at what conclusions can be drawn from the findings and what recommendations could be made.

**CHAPTER 2: Literature Review**

**2.1: What is STEM**

Perhaps given the focus of this research it could be assumed that this question would be easy to answer. However, through a review of literature, it has become apparent that is not the case.

STEM, now a widely used term to refer to Science, Technology, Engineering and Mathematics, hasn’t always been STEM. It was first coined as the slightly racier acronym of SMET by the National Science Foundation (NSF) in the 1980s. After the suggestion it could be mistaken for the word “smut” it was rearranged and became the much catchier STEM (Sanders, 2009). In the last decade or so the acronym STEM has gain traction as a commonly used term, not only in education but also in certain sectors of wider society associated with STEM industries and policy making. Unsurprisingly, as with many buzz words, despite most people having heard the term it is still not well understood and lacks any sort of solid definition. Indeed, the public, out with education and STEM industries, seem to have little to no idea about this term (Angier, 2010). It is, therefore, important to look at what STEM means to different stakeholders, such as educators, policy makers and people within industry, as this will influence aspects of their relationship with it and impact the importance place on STEM education, what funding STEM development will receive and how they feel STEM education should be delivered (Sanders, 2009).

Within the stakeholders something that appears to be almost universally agreed is that STEM stands for Science, Technology, Engineering, and Maths. Beyond this, perceptions of the actual meaning become very individual and open to interpretation. Breiner (2012) agrees that the meaning of the acronym is generally well understood but they question whether the acronym says enough and if the different partners in STEM interpret it in the same way. Perhaps in general terms these partners can come to a consensus, but the finer points seem to be where the confusion starts.

To look at STEM from an education perspective there seems to be a disconnect between how different educators’ view STEM and how STEM education should be delivered. STEM education can be delivered in two ways. The first way is what would be considered a STEM based education system which promotes the different facets of STEM but continues to teach them in a segregated manner with little to no crossover between subjects. Indeed, irrespective of views held on how STEM should be delivered, most education establishments continue to deliver STEM subjects as traditional separate disciplines. Some look to the curricular models being used as the basis of this lack of development in the delivery of STEM with some believing that it is a lack of coordination and common focus that is creating the difficulties (Breiner *et al,* 2012). Struyf (2019:1387-1388) believes that:

‘STEM education in primary and secondary schools focuses on theory rather than on application and experiential learning and is taught in a way that reinforces a disconnect between the different STEM disciplines.’

The other way STEM education can be considered is an integrated STEM education approach, often referred to as iSTEM. This integrated approach is seen as the modern approach to STEM education and has gain considerable traction in recent years with many believing this to embody what the acronym is trying to convey (Lobov, Reid and Yamamoto*,* 2010). Most researchers writing about integrated STEM have a fairly similar view on what that means with most settling on the approach to teaching the content of two or more of the STEM domains to show a connection between the disciplines and to connect them to real world problems (Breiner *et* al, 2012; Moore *et al,* 2014; Kelley and Knowles, 2016; Simoncini and Lasen, 2018; AlAydaroos, 2019; Siregar *et al,* 2019; Struyf *et al,* 2019; Navy *et al,* 2020; Khan and Kashif, 2020; Li *et al,* 2020). The move towards this integrated model is due to those involved in teaching and working in STEM realised that traditional methods of delivering subjects as distinct disciplines is not how STEM is done in the real world. In STEM industries multiple different disciplines are continually collaborating to find a workable solution to a problem (Breiner *et al,* 2012). This type of integrated learning with real world connections can be grounded in situated cognition theory which was proposed by Brown in 1989. Situated cognition theory looks at how understanding the ways the knowledge and skills gained can be applied is as important as the knowledge and skills their self, essentially the context of learning is as important as learning itself (Putnam and Borko, 2000). Kelley and Knowles (2016) believe that this integrated learning should not only be grounded in real life problem solving but should also include outside participants from the wider STEM community, like practicing scientists or engineers, to truly give context to students learning. In addition to this integrated approach, due to its focus on actual problems to be solved, allows students to have more opportunity to lead and have an active role in their education rather than passively receiving information in lecture-style lessons, this student-centred learning environment is inspired by the constructivist learning theory (Baeten, Dochy and Struyven*,* 2013; Stuyf *et al,* 2019).

The final way that STEM can be viewed is that it doesn’t exist at all beyond a simple acronym and is not something that should be used to develop education policy. Some feel the use of STEM is nothing more than the new buzz word which is clouding the true issues facing science and mathematics education along with confusing what science truly is, a means of discovery and applying ideas (Angier, 2010). Indeed, there is quite passionate push back on iSTEM from some in education. McComas and Burgin (2020) are particularly scathing of the iSTEM movement. They believe that, while the projects that are promoted as iSTEM may be highly enjoyable for the students to participate in, they risk the deeper learning of science and mathematics is being lost. They suggest that there is a danger that, despite science and mathematics being the foundation for engineering and technology, all four disciplines will be given equal weighting and be detrimental for the continued development of high-quality science and mathematics teaching. This critique of STEM education is supported by several other researchers and educators, especially in the science community (Clough and Olsen, 2016; Pleasants *et al,* 2019; Zeidler, 2016; Zeidler *et al,* 2016).

**2.2: What is the importance of studying STEM?**

While trying to define STEM and STEM education may seem perplexing, explaining the importance of studying STEM is much easier.

The world is changing at an incredibly pace. The development of technology has progressed at an unprecedented rate and is now an integrated part of all aspects of industry. This rapid development has been described as the Fourth Industrial Revolution and is being driven by digital technology (Hafni *et al,* 2019). Jobs within STEM industries are considered the ‘jobs of the future’ (Black *et al,* 2021) with the predictions suggesting up to 75% of future jobs will require the skills that are developed through STEM education (Simoncini and Lasen*,* 2018). Hafni (2019) believes that jobs such as data analyst are one of these ‘jobs of the future’ where there will be a huge requirement to deal with our reliance on technology and ‘Big Data’. It has also been well documented that STEM fields are drivers of innovation and economic growth with most countries recognising this and moving to encourage the development of these industries (Görlitz and Gravert, 2018). Governments also recognise the global challenges facing the world such as climate change, overpopulation, health and declining energy and water sources require a highly skilled workforce to find solutions to these issues (Kelley and Knowles, 2016; English, 2016). STEM education and training are also linked with higher wages and skilled occupations (Black *et al*, 2021; Navy *et al*, 2020). STEM occupations are seen as high-status positions and often come with rewards such as relatively high personal income and social prestige (Xie, Fang and Shauman*,* 2015). The shortage of workers with the required skills to take positions within the STEM labour market has long been a concern and it is only going to get worse as jobs move more towards STEM-based industries. It should be noted that to simply state that there is a shortage of suitable candidates to fulfil the requirements of the STEM industries is not an entirely accurate statement to make. Certain areas of STEM industries are well supplied to the point of over supplied, with software development and computer information showing a strong position with regards to supply. There is also an argument that the issue may not be a lack of suitably qualified workers but poor incentives, such as pay, to encourage workers to enter and remain in the industry (Camilli and Hira, 2019).

Teachers involved in the delivery of STEM subjects are under no illusion as to the importance of STEM to society and to a student’s ability to be successful as a member of that society. The biggest advantage a strong STEM education can give to students is the development of a wide array of skills that will benefit them in any career they choose to enter. Employers in all industries have come to understand the advantages of the skills developed through STEM. The skill set required of nearly all occupations has changed in recent times with the continued development of new technologies and processes. Due to this the ability to use critical thinking, problem solving, reasoning and collaboration has never been more important (Siregar, 2019). These soft skills are what STEM education develops and what allow individuals the resources to adapt to changing workforce requirements. Employers are always on the lookout for individuals who can help drive their business forwards, critical thinking and problem solving instil the requirements for curiosity, creativity, scepticism, analysis, and a logical approach to tasks and problems (Hafni *et al,* 2019). These skills allow an individual to apply their knowledge to solve real-world problems.

**2.3: Barriers to Studying STEM**

Despite being able to identify multiple reasons why STEM education is so important the numbers entering further and higher education in this area and, ultimately, STEM careers has not increased in many years. Representation in STEM is especially poor for a number of specific groups such as, with those from lower socioeconomic areas, those who are part of racial/ethnic minority groups and those who identify as women or as a gender other than that assigned at birth (AlAydaroos, 2019; Casad, Petzel and Ingalls*,* 2019; Clements *et al,* 2021; De Loof *et al,* 2021; Khan and Kashif, 2020; Shin, Levy and London*,* 2016; Van der Vleuten, Steinmetz and Werfhorst*,* 2018; Xie, Fang and Shauman*,* 2015).

The gender gap within STEM education and STEM fields is perhaps the most well-known and explored barrier. Women, despite making up over half of those graduating from universities, are still significantly underrepresented in certain STEM fields. Most notably in mathematics, physical sciences, engineering, and computer science (Casad, Petzel and Ingalls*,* 2019; Xie, Fang and Sahuman*,* 2015). The reasons for this underrepresentation have long been hypothesised with many early researchers attempting to identify a biological gender-based difference (Baron-Cohen, 2003; Ceci and Williams, 2010), thankfully, this has been all but disregarded with external, non-biological factors being investigated as the root cause of this disparity.

One of the major factors that appears to influence women’s participation in STEM is what would be called the stereotypical social expectations of gender, this being the roles that men and women are expected to fulfil in our society. These are deeply ingrained in our subconscious and, while attitudes are shifting, can be very difficult to change (Shin, Levy and London*,* 2016; Van de Vleuten *et al,* 2018; Xie, Fang and Shauman*,* 2015). These expectations can result in parental and peer pressure negatively influencing women’s perception and ambition within STEM. This stereotypical view of roles has become very pervasive within STEM going so far as to create an expectation that if one was to meet someone working in STEM that they would be a white male. This lack of diversity has created a threatening academic environment within STEM education, particularly in higher education establishments such as universities, in which those that perceive their selves to be part of a group with a stigmatised social status experience social identity treat. This type of threat comes from believing that characteristics which are permanent, uncontrollable, and not concealable, such as gender, race, and ethnicity, will be used to make judgements about that person and could lead to discrimination (Casad, Petzel and Ingalls*,* 2019). Casad (2019) concluded that when in a situation where women experience social identity threat, they are more likely to experience lower self-control along with poorer academic, mental, and physical health outcomes. Essentially, they become so worried about any poor performance being attributed to them being a woman that they begin to perform more poorly in a self-fulfilling prophecy. Due to this many women find it is detrimental to their wellbeing to remain in the field and leave (Shin, Levy and London*,* 2016; Van der Vleuten, Steinmetz and Werfhorst*,* 2018).

The reasons for the gender gap within STEM are also attributed to the lower uptake of STEM subjects by those who are part of linguistic and ethnic minority groups, with feelings of isolation and struggles with cultural difference in higher education establishments being quoted (Xie, Fang and Shauman*,* 2015). Interestingly, the enthusiasm for STEM education and in pursuing a career within STEM is comparable between all racial and ethnic groups; this suggests that there are other factors at play with regards to barriers for those from ethic minority backgrounds when compared to gender (Xie, Fang and Shauman*,* 2015). These other factors have been suggested as socioeconomic and cultural ones. Students from ethnic minority groups are more likely to come from poorer communities where families are more likely to have less education and higher rates of unemployment (Kao and Thompson, 2003). Students from these areas are more likely to attend a school that has larger class sizes, fewer advanced STEM courses and poor-quality learning materials (Museus *et al,* 2011). There are also cultural beliefs, such as those held in the United States of America, that achievement in STEM subjects, such as mathematics, depend on native aptitude or ability rather than through hard work and effort (it should be noted this belief has no basis in truth with no studies to back up these ideas) (Clements *et al,* 2021). This belief has led to a perception that STEM is an area of study more suited to those from a White or Asian background with the disparities between these and other ethnic groups emerging as early as primary school and becoming more pronounced as they progress through their school career.

While the socioeconomic impacts are often disproportionately felt by those of ethnic minority groups they are not confined to these groups, with poverty affecting students from all ethnic backgrounds. As discussed above this can lead to poorer quality educational experiences. STEM subjects can be especially difficult to deliver without adequate funding due to additional requirements for often expensive resources. While subjects, such as science, can be delivered in a purely theoretical way they lose the development of practical skills and the development of the ability to utilise knowledge to solve real life problems. Students who have limited experience in the practical aspects of science and technology are less likely to see STEM as a future career option, they are also less likely to be able to compete with their peers from more full STEM education backgrounds with regards to university places and job opportunities (Wang, 2013). Students from underprivileged background are also less likely to experience exposure to STEM out with what is provided in school due to being unable to access ‘STEM enrichment experiences’ such as visiting science centres, participating in extracurricular STEM clubs and attending summer STEM camps (Archer *et al,* 2012; Schmidt *et al*, 2020). Poverty and instability in the home are also, unfortunately, factors that tend to be generational, affecting multiple generations of the same family with most finding it incredibly difficult to break free of the cycle (Akram, Maitrot and Denk*,* 2020).This can mean that support within the home with subjects like maths and science or exposure to these subjects can be lacking due to poor educational outcomes and experiences of the parents for all the same reasons stated above. Students may also be encouraged to leave school and gain employment in low skilled work as soon as possible to help with the financial situation within the home, therefore, not continuing their studies into further or higher education which is normally required for a career within STEM (McKinney *et al,* 2013).

Perhaps the one apparent barrier for students engaging with STEM that would be the easiest to remedy is the role played by the teachers delivering these subjects. Positive STEM experience in early childhood, such as those delivered in Primary school, are incredibly important for developing STEM competency and thinking skills that are needed for later STEM engagement (John *et al,* 2018; Kermani and Aldemir, 2015). While this importance has been identified primary educators still seem to be unwilling to teach STEM with the same focus and enthusiasm as they teach language and social emotional development (Tu *et al,* 2006). There appears to be a trend in primary education where teachers do not feel prepared or confident enough to deliver full and interesting STEM experiences. Clements (2021, p.158) believe this is because:

‘Early childhood teachers frequently hold negative dispositions and beliefs about mathematics and science, including dislike, trepidation, fear and doubt in their own efficacy.’

This ‘fear’ of STEM may have been developed at a very early stage, perhaps even before entering the teaching profession. Navy (2020) looked at the perceptions of preservice teachers to STEM and found that they were unsure of what STEM was and why it is of such importance. They suggest that this could be due to their own experiences in education, stating ‘preservice teachers…are both products and producers of STEM education system’ (Navy *et al,* 2020, p.43) and as such can carry these feelings into their own professional practice. This feeling is echoed by AlAydaroos (2019, p.364) who states:

‘The general lack of interest… in STEM could mean that teaching STEM had not been carried out effectively in the past, resulting in students’ disinterest. This disinterest is perpetuated in adulthood resulting in an establishment that does not pay attention to STEM subjects and how they are taught.’

This decrease in interested leads to a decrease in confidence and motivation in the delivery of STEM subjects from teachers and this will ultimately result in a decrease in positive perceptions of STEM in students (Khan and Kashif, 2020).

Teachers, particularly those out with STEM specialities and those in primary education, require suitable training to be able to deliver STEM in an enthusiastic and exciting manner. Professional development must be focused on developing teachers’ abilities to deliver STEM through group-based projects and allowing students to work on real life problems from the research stage through to development and production of a solution. This allows teachers to shifting away from the traditional lecture-based teaching methods (AlAydaroos, 2019; Clements *et al,* 2021; Khan and Kashif, 2020). This shift can allow teachers to change the way in which they motivate their students. Many teachers, when unsure of their own ability to deliver a topic, can find it difficult to relinquish control of the lesson, leaving very little room for students to explore a topic independently. This causes a decrease in motivation in the students. If teachers feel more empowered and confident in their delivery of a lesson, they can allow students to have more autonomy in their learning allowing them to develop their problem-solving skills and feel more motivated in their learning (De Loof *et al,* 2021).

**2.4: How is policy influencing the delivery of STEM education?**

With all the barriers set out above it is perhaps sensible to look at how policy is influencing this. The focus will be on Scottish policy as it is of most relevance to this research project.

The Scottish government presented their vision for STEM education in 2017 as the ‘Science Technology, Engineering, Mathematics – Education and Training Strategy for Scotland’ was released. This document laid out the Scottish government’s roadmap for leading Scotland into the future as a world leading STEM nation. Their aims were not only to ensure suitable education and training to those who would go on to work within Scotland’s STEM industries but also that all people in Scotland are STEM literate and can engage fully with the ever-changing world around them. This five year plan, running from 2017 to 2022, had a number of expected results including an increase in the number of people undertaking STEM-related learning; an increase in confidence of delivery of STEM learning especially in early years, primary and community settings; reductions in the equity gap relating to gender, deprivation, race and location; an increase in the understanding of why STEM is important for everyone; an increase in collaboration between schools and industry; and, ultimately, an increase in employment in STEM-related occupations.

To back up the implementation of the Scottish governments STEM strategy they also produced an evidence base (2017b). This was an interesting document as such a detailed analysis of STEM skills, education and occupations has not been undertaken before. The difficulty of measuring such areas is noted with an admission that ‘STEM is more difficult to define in data terms…’ (Scottish Government, 2017b, p.4). The document notes that the percentage of total employment designated as STEM is 37% for Scotland, higher than the average for Great Britain which stands at 32%. This shows why the promotion and development of STEM is of such importance to Scotland now and for the future. It also shows the gender bias within the STEM workforce in Scotland with 95% of those employed in construction of roads and railways being male, while 82% of those employed in medical and dental practice activities are female. This gender bias in industries is something that the Scottish government wants to and tackle with their STEM strategy. One of the other major changes they wish to enact is the participation of the whole family and community in STEM. Many young people from minority ethnicities and areas of deprivation do not view STEM education or a career in a STEM industry in their future, this can be due to a lack of encouragement and engagement from their families and communities. By giving these groups access to community STEM experiences, such as Science centres, they will gain the confidence to participate in STEM and they will be more able to encourage and support young people to pursue a future in STEM.

This strategy was supported by other policies such as ‘Developing the Young Workforce’ (2015) from Education Scotland which was developed in response to the Scottish governments own strategy on youth employment release in 2014. Developing the Young Workforce (DYW) looks to provide young people with more access to vocational education and training in addition to the traditional education offered in secondary and further education. One of the main aims was to develop the links between education and employers. This has been achieved by establishing regional networks between education establishments and employers in their area. In 2020 a DYW information update was released that introduces STEM as a focus within DYW. It introduced programs, such as RAiSE (Raising Aspirations in Science and STEM Education) which aims to improve the STEM offerings within primary schools which will provide the STEM base for students as they transition into secondary education. These types of programs are being mirrored in other countries, like Australia who have also embedded the need to promote STEM in early years education through their Early Years Learning Framework (EYLF) (Australian Government Department of Education, Employment and Workplace Relations, 2009). America, who really started the STEM movement, have created several comparable programs such as TRAIL (Teachers and Researchers Advancing Integrated Lessons in STEM), a program that seeks to increase collaboration between science and technology teachers to improve integration of these subject within schools (Kelley and Knowles, 2016). Germany have gone so far as to reform the entire curriculum to increase mandatory time spent in science learning (Görlitz and Gravert, 2018).

The plans set out by the Scottish government were bold and the expected results, if achieved, would change the face of Scottish education and industry. The 2022 STEM strategy refresh gave an insight into how well the goals of the 2017 publication had been achieved. Perhaps the greatest success story of the strategy has been the promotion and implementation of apprenticeships. Modern apprenticeships in STEM have been given funding priority leading to an increase in uptake; while Foundation apprenticeships have been developed and expanded with more than half of all those entering doing so in the STEM-related frameworks; and newest addition to the apprenticeship opportunities, Graduate apprenticeships, have proved to be a great success with 13 of the offered frameworks in STEM-related subjects. Of the three apprenticeships offered, female apprentices are most likely to study at the Graduate apprenticeship level with quite a lot of work to correct the gender imbalance in all apprenticeships still necessary. For programs like RAiSE, which was aimed at primary school STEM education, there has been some success. For the schools who were involved it has been a positive experience and has allowed more professional development opportunities and development of collaborative networks. The building of STEM capacity in early and primary settings must remain a focus and initiatives such as RAiSE must be rolled out to all local authorities to ensure that it does not contribute to attainment gaps between different regions. Professional learning for practitioners in all sectors of education has been successful with SSERC (Scottish Schools Education Research Centre), The Royal Highland Education Trust and the Easter Bush Science Outreach Centre (EBSOC) all providing top class training opportunities at all levels. It would be impossible to discuss all the initiative and programs that have been implemented to encourage students to engage and be enthusiastic about STEM and while the Scottish governments STEM strategy is being extended for at least another two years for not meeting many of its targets the circumstances that have impacted all areas of education, and the whole world must be considered.

In 2020, COVID-19 arrived. On its arrival all semblance of a normal life disappeared. The way education and training were delivered had to evolve as we tried to deal with the pandemic. The delivery of STEM education, inherently a hands-on area of education, lost a fundamental aspect of the learning. The attempts by Education Scotland and their partner agencies to continue to provide suitable learning experiences for young people and for professionals is to be commended. Their commitment to extend the STEM strategy is also a positive move. However, due to the pandemic the major focus for policy at this time must be to address the increase in the attainment gap caused by the differences in education received when schools moved online. Education Scotland’s document ‘Recalibrating Equity and Social Justice in Scottish Education: Bouncing forward after COVID-19 lockdowns.’ (2021) sets out the six priorities for all in education, and, unfortunately, STEM is not a focus of this ‘bounce forward’. The need to ensure that no young person is left behind is, of course, of critical importance and must be prioritised.

**2.5: What strategies can be used to increase engagement in STEM?**

In addition to the policy being put in place by governments to try and tackle the lack of enthusiasm and interest in STEM several research papers looked at what strategies are effective in increasing engagement in STEM.

Some of these strategies have already been alluded to above. One of these is the direct effect the style of teaching has engagement in STEM. De Loof (2021) looked at whether the style in which a teacher leads STEM learning has an impact on how pupils view STEM. They found that when a STEM teacher shows what is called autonomous motivation style, pupils are more likely to be motivated and engaged by the lesson. This type of motivation style allows pupils to feel more in control of their own learning which in turn increases their motivation and engagement. This study relied on only the teacher being the source of motivation and engagement which is a narrowminded view of how young people learn and does not take in to account other influences on young people such as family and peer groups.

The German model (Görlitz and Gravert, 2018) of changing the entire structure of the curriculum to encourage more engagement in STEM is a more extreme way to bring about change. In Germany states are free to set their own educational policy, Baden-Württemberg decided to refocus their education system to what they saw as the core subjects of German, foreign language, mathematics, and natural sciences. The study of these subjects became compulsory to an advanced level along with assessment in all core subjects to gain their high school diploma, a prerequisite for admission to German universities. It was found after this reform that male students were more likely to apply for STEM-related university courses than before. This effect was not, however, found in female students. This difference in outcomes for male and female students may be due to future career option or it may be linked to barriers discussed earlier such as stereotyping.

Shin (2016) discuss the issue of stereotypes, the negative impact they have on certain groups participation in STEM and what can be done to change this. Many people when they view STEM hold onto negative stereotypes about who can and cannot study and participate in it. These are discussed extensively in the previous section on barriers. They looked specifically at two stereotypes, that people who do STEM are white males and that people who do STEM are innately gifted and have natural ability. They hypothesised exposure to biographies that showcase role models which went against these stereotypes would increase interest in STEM from students from underrepresented groups. Their finds were positive and showed that exposure to more diverse role models increases engagement and enthusiasms for STEM. This research study shows clearly that young people need to see their selves represented to feel they can aspire to that position.

Beyond looking at how to tackle the barriers to STEM some looked at the impact of using the integrated method to deliver STEM education as opposed to the traditional discreet delivery of the subjects. Due to the enthusiasm with which some have promoted this new integrated form or STEM education the expectation would be that it would increase interest and enthusiasm in student. Struyf *et al* (2019), however, did not find this to be true. While there is an initial slight increase in engagement on switching to an integrated model this was not sustained or found to be significant. The explanation for this increase could be moving to a more student-centred learning environment, which is one of the major underlying principles of iSTEM, rather than the actual integrated nature of their learning. To this end it would seem this agrees with De Loof above in that it is more to do with the learning environment and style of instruction than the actual content of the learning.

The strategies that seem to be of most interest, and are the focus of this study, are those that provide students with science and STEM experiences outside those of a normal classroom and curricular setting. While there is no denying the impact that early experience can have on a child’s identity, whether experience of science and STEM in those formative years influence the education and career trajectory is still being studied. The experience in this period of early childhood are usually informal, outside-of-school experiences. This could be in the form of family encouragement, especially where parents are occupied in STEM fields; STEM related hobbies; and participation in out-of-school STEM clubs. Out-of-school STEM programs have been utilised quite widely in more recent years with many targeting underserved young people for engagement (Schmidt *et al,* 2020). Participating an any of these experiences increases their STEM identity. STEM identity is where people perceive their selves to be part of a group or to be viewed by others in a certain way i.e., as a scientist or an engineer. When they gain this identity, they are far more likely to continue into a career in STEM and feel a sense of belonging within that field (Dou *et al,* 2019). Once again this draws us back to the barriers previously discussed, particularly economic status. Those living in poverty are far less likely to have family members who work within STEM and are also less likely to be able to access experiences like science museums and STEM camps or groups.

While experiences provide out with school can be very effective it can be difficult to encourage young people to participate. Due to this it can be easier to try and implement a program in school that can be done during class time or at lunchtimes. The basis for any of these programs will be Project-based Inquiry Learning (PIL). By taking part in a project students get to work through a real-life problem from the beginning all the way through to the development of a solution. Time must be taken at the end of the project to allow for reflection, it is through this reflection that students will be able to identify the learning that has taken place. An independent assessment of a student’s journey can be incredibly impactful with students feeling like they have gain new knowledge through their own hard work rather than being given the knowledge through more traditional lecture-based learning (Ng and Adnan, 2018). Students find these types of learning experience ever more valuable when they can place them very firmly in a real-life context. Teachers in the United Arab Emirates used the countries developing space program to provide several different learning experiences all linked to space and the work being carried out by their spacy agency. This allowed for real technology and scientists to be utilised to enhance the learning taking place. They found hands on, project-based learning using real-world examples and experiences was more valuable in encouraging students to pursue further education and careers in STEM than the traditional school-based learning experience (AlAydaroos, 2019).

**2.6: Conclusion**

STEM is not easy to define, nor is how best to deliver it in an education setting. Moving forwards, encouraging more young people to pursue careers in STEM will require a multifaceted approach with all partners, from government to industry and obviously education, working together to identify the real issues and how we make real changes. What has been made clear is that STEM jobs and industries are the future and work must be done to ensure young people are ready to take their place in that future.

**CHAPTER 3: RESEARCH METHODOLOGY**

**3.1 Introduction**

In the literature review of the previous chapter the importance of encouraging pupils to study STEM and to view it as something accessible to them is clear. The aim of this research is to explore how providing opportunities to participate in STEM out with the normal curricular experience changes pupils’ perception of STEM subjects and their desire to participate in them. This chapter will provide detail on how this aim was achieved.

**3.2 Action Research**

Action research is a way to gather data about a particular social situation while simultaneously attempting to make improvements within it (Munn-Guddings, 2021; Marshall, 2011; Hopkins, 2008). Within education the logical researcher is the teacher, taking on the role of practitioner researcher. They are most likely to identify issues within their practice or the system within which they work. They are also best placed to observe and gather data as well as the individuals that will see the benefits of changes made (if positive of course) (Punch and Oancea, 2014). Enhancing the lives of pupils is the main goal of action research but it should not be forgotten that a secondary aim is to enhance the lives of teachers and educational staff involved that can benefit from the changes implemented (Mills and Butroyd, 2014).

*Figure 1* below is based on the Action Research Cycle as found in Ferrance (2000, p.9). This shows the steps that must be taken during action research. It shows that it is a never-ending process of questioning, implementing, and evaluating. This is the way that teachers should be approaching their practice as standard, so it is easy to see why action research is a natural progression of their normal practice. However, action research, as discussed in Townsend (2012), should not be considered a ridged sequence of steps that must be carried out in that order without deviation. It is a process that is ongoing and allows flexibility to continue to improve processes and practice.

Diagram

Description automatically generated

Figure 1: Action Research Cycle.

The first step in action research is to identify an issue worthy of further investigation. For this researcher that is the lack of participation and engagement from students in STEM, which is of particular concern in the BGE phase of education. As the importance of education in STEM to future career outcomes has been made clear it would be remis of this researcher to not attempt to change these views.

The next steps of gathering and interpreting data will be covering in the remained of this chapter. It should also be noted that while action research should be an ongoing process, due time constraints this research project will focus on the completion of one cycle.

**3.3 Mixed Methods Research**

Mixed method research uses both quantitative and qualitative methods to gather data. This allows the researcher to draw on the strengths of quantitative and qualitative methods while offsetting their weaknesses and provides a more complete account of the area being researched.

The research questions being looked at lends their self to using a mixed method for obtaining the data. With any research involving people a balance must be found between fact and feeling. The quantitative data gives the scale of the issue and the impact of the intervention in an impersonal manner, allowing the researcher to measure the effectiveness of the methodology, in other words to gather the facts. The qualitative data gathered allows the personal opinions and impacts to be understood, considering the individuals and personalities involved, this is where feelings are considered.

The design of the qualitative research within this study would be considered non-experimental. This is due to two factors; the lack of control available over external factors which could affect the results and that randomisation and control groups are not possible, this is due the social and ethical considerations that control such research (Muijs, 2004).

Quantitative deals with numbers and statistics. It is the preferred method of data collection for scientific and economic studies. It has, despite previously being the dominant strategy for data gathering in social and educational research, found itself an uneasy bedfellow when it comes to education and action research. There is a feeling it takes a positivism approach and reduces cause and effect to a linear form of thinking, ignoring the people involved and their personal feelings and circumstances. While this is true to an extent, its epistemological position which influences the process of gathering and analysing quantitative data obtained in this study has been considered carefully, thinking about the individuals involved and trying to allow them to convey their thoughts and feelings in a way that could not only be quantified by this researcher but also to allow them to clarify their own thinking in a concise way.

Qualitative research moves for a more personal, on the part of the participants, approach to data collection. The qualitative aspect of the methodology gives scope for the participants to answer questions in their own words and in a more natural manner than the quantitative method allows. The way in which qualitative data is collected has a natural progression of thought. There are three steps, or features, to look at when deciding on the most appropriate method of qualitative data collection, these are the ontology, the epistemology and ultimately the methodology (Blanch, Durrheim and Painter 2007). The ontology, being the *‘views about the social world, and social phenomena’* leads to the epistemology, ‘*views about how knowledge should be produced’* (Clark *et al,* 2021, p.7) which will inform the methodology selected for data collection and issues that may arrive from these methodologies. In this study a constructivism approach is used to look at the experiences of the participants and how it informs their beliefs and opinions.

**3.4 Data Collection and Instrumentation**

For this study extensive primary data was gathered to allow conclusions to the research question(s) to be drawn. This was gathered using questionnaires and in-person interviews.

**3.4.1 Questionnaires**

Questionnaires are a useful tool used extensively in research. They allow both quantitative data and qualitative data to be gathered in a non-invasive manner. The development of a questionnaire requires is not so straight forward as some may assume. The questions included must be selected after the consideration of several factors. The primary amongst these being will the questions permit information to be obtained that allows the research question(s) to be answered. The second consideration must be the participants, will the questions be understood and what impact on their personal time is acceptable? The final consideration is for the researcher, including but not limited to their own time constraints and easing the burden of data analysis with larger groups (Bell and Woolner, 2012, Cohen, Manion and Morrison*,* 2018). While it is advisable to do some pilot testing prior to the roll out of a questionnaire it is not always possible, such as in this case, due to time constraints (Hambleton, 2017).

Questionnaires were given to all participants of the projects running, both classroom-based and extracurricular, on commencement and on completion. All participants are part of the S2 cohort with mixed abilities, genders, and ethnicities represented. Participants were given clear instructions on how to complete the questionnaires and that they were in no way required to complete it if they did not wish to.

The questionnaire (Appendix A) included qualitative questions, in the form of Likert-type responses and multiple-choice questions, and qualitative questions in the form of short written responses and open-ended questions. This wide range of question types were employed to allow a wide range of information to be obtained as quickly and easily as possible.

Open-ended questions were used in this study to gain insight into the perception of what people in STEM look like, their backgrounds and what type of people they are. This will assist in answering the research question by identifying stereotypes and perceptions that are held and whether these change over the course of the intervention.

Short written responses allow the respondent to answer in any way they wish but does constrain the length the answer can be. These types of questions can force the respondent to be more direct and to the point with their answer. There is, however, the risk of respondents finding the question overwhelming and simply writing ‘I don’t know’. Researcher must be aware of the potential failing of questions of this type when including them in a questionnaire and the risk they will provide no meaningful data.

Closes questions are good at providing quantitative data. Closed questions such as multiple-choice rely on the potential answers to a question being predicted. Respondents then select the answer that fits most closely to what they think. The drawback to this type of questions is that the potential answers may not be truly representative of the respondents’ views. Likert-style questions do not have this problem as they ask respondents to rate their feeling on a scale. The size of the scale will change the degree of accuracy with which the respondents can convey feelings on a given statement (Briggs, R.J., 2012, Tymms, P., 2021).

The drawback to using questionnaires to gather much of the data for this research is that the respondents are not required to answer or provide useful data if they do not wish to. When using questionnaires with students there is a risk that the lower attaining students, those historically with poorer attitudes towards STEM, are less likely to provide answers and engage with such data gathering methods.

**3.4.2 Interviews**

Interviews are a useful data gathering tool for qualitative research as they move away from seeing people purely as source of data and towards a building of knowledge through shared understanding of experiences and feelings, they are a social, interpersonal encounter between the interviewer and the interviewee (Cohen, Manion and Morrison*,* 2018). The focus is far more on the thoughts and feelings of the interviewee on the issues being discussed rather than on extracting a direct answer.

The benefits of interviews are that they are a flexible and dynamic method of data gathering. While the interviewer is in control of the structure of the interview through the order and content of the questions, there is scope for a more personal interpretation of these questions by the interviewee and allows for spontaneity in the answers given. To facilitate this, it is the job of the interviewer to establish trust between participants, engage their curiosity on the issue and encourage a naturalness to their answers.

Participants were recruited voluntarily where everyone taking part in the projects was offered the opportunity to be interviewed. Those that wished to take part were given plain language statements and consent forms for both their parents/guardians and for their selves. A total of seven were selected for interviews which were conducted one-to-one within the school. Individual interviews were chosen to allow interviewees to feel they could be as honest as they wished without worrying what their peers may think. As Baumfield (2008, p.74) states:

‘Individual interviews enable you to explore issues in depth and afford the interviewee a confidential, safe place to talk.’

As with all data gathering methods there are drawbacks to the use of interviews. The first being that it is a time-consuming task to undertake through the organising and conducting of the interviews to the analysis of the data obtained. There is also an unpredictability about interviews, they may fail to provide the researcher with useable data or, perhaps, provide unexpected data that could change the fundamental of their research (Mears, 2021).

The interviews conducted during this research project were of the standardised open-ended style. The same five questions were asked during each interview session (Appendix B) and were kept simple with participants being asked to answer honestly and with as much detail as they chose. Each participant was interviewed on completion of the projects. Their responses were written down during the interview, these were then shown to the participant at the end of the interview to ensure they were happy that it had been recorded accurately.

**3.5 Validity and Reliability**

It is imperative that a piece of research is considered valid, without validity the research has no meaning. The definition of validity is, unfortunately, open to interpretation and the idea of validity is different depending on whether the research is quantitative or qualitative. In this study both approaches for gathering data are used therefore multiple approaches to ensuring validity must be used. Broadly it can be assumed that validity can only be achieved if the method used to measure impact of the study does in fact do just that or as Clark (2021, p.155) states ‘whether a measure of a concept really measures that concept.’. Along with this, the interpretation of data obtained must warrant the conclusions drawn. Selecting the wrong method of data gathering or gathering too few results puts the validity of a piece of research at risk.

Reliability is concerned with the replicability. Essentially, how possible is it for other researchers to replicate the study and obtain the same results. To increase reliability of a study the consistency of measures must be considered during the construction of the methodology. In this study questionnaire and interviews were used to collect data. Both these methods of data gathering have advantages and disadvantages with regards to reliability. Questionnaires, when conducted anonymously, can increase reliability as participants are more likely to be honest in their responses, however, non-completion and misunderstanding of questions cannot be addressed. In interviews the advantages and disadvantages are essentially the complete opposite. Interviewees are more likely to be dishonest in their responses but there is also more scope to identify and rectify misunderstanding (Cohen, Manion and Morrison, 2018).

**3.6 Data Analysis**

Once the data had been collected the next step was analysis. The type of analysis done was dependent on the type of data collected, quantitative or qualitative. With a mixed methodology study such as this one it is the research question(s) and the types of data collected that will drive the selectin of appropriate data analysis techniques (Hibberts and Burke Johnson, 2012)

The quantitative data obtained was non-parametric as there is no data on these questions available for the general population, therefore no assumptions about the cohort can be made (Cohen, Manion and Morrison*,* 2018). The analysis of the data obtained only gives information about the groups involved in this study.

For the Likert-type responses the average of the responses will be calculated. The numerical values obtained from these questions would be considered nominal values as they denote categories rather than true values, answering 2 on the scale does not mean that they like something half as much as someone who answered 4. Due to this, descriptive statistics will be used to present the data.

Multiple choice question will be similarly analysed using frequency of answers to give an overview of the opinions held.

The short answer and open questions will require a different approach. Coding allows large quantities of qualitative data to be organised into manageable and comprehensible portions. The process of coding involves creating categories into which words and statements conveying similar ideas or pieces of information are organised. There are two approaches to coding, pre-ordinated categorisation involved the categories being decided before the analysis of the data. Responsive categorisation, on the other hand, involved the categories being decided during analysis with the data itself guiding the number and types of categories derived. Of the two approaches, responsive categorisation will be used in this research. This is because it is less likely to be influenced by researcher bias. However, I am aware that is nearly impossible to be completely responsive as during construction of the research question(s) preconceived ideas regarding likely outcomes will form.

Once the qualitative data has been coded, content analysed can be carried out to see the most common themes emerging. The frequency of a category being used can be analysed to give an overall view of opinions being presented.

The above data analysis must be completed on the data collected at the beginning and end of the study. These two sets of data must then be compared to one another. This will show if the intervention has had an impact. For the most part this will be done through direct comparison of the frequency of the responses.

The interviews will be conducted on conclusion of projects and will be used to give more context and personal feeling to the results. These responses will not be analysed using coding or any other data analysis tool but will be used to give voice to the respondents and, perhaps, gain a more nuanced understanding of attitudes to STEM.

**3.7 Ethical Consideration**

Ethical consent and approval were sought from and granted by the School of Education Research Ethics Committee at the University of Glasgow. To ensure all aspects of this research project were conducted in a fully ethical manner the guidelines and values as set out by the British Educational Research Association (BERA) (BERA, 2018) were followed. This research project is also informed by GTCS ‘Codes of Professionalism and Conduct’, due to the researcher being a teaching professional. The GTCS code incorporates principles from the UN Convention on the Rights of the Child and the GTCS ‘Standards for Full Registration’ (GTCS, 2012).

Permission from the school to conduct the research was obtained, along with the cooperation of other teachers to assist with delivering the intervention in various settings. All were given a full explanation of the research including purpose, and projects to be delivered.

Participation in interviews was completely voluntary with everyone involved in the projects given the option to take part. For those that wished to participate in interviews plain language statements (PLS) and consent forms were given to all students to sign, and as they are under 16 years of age, PLS and consent forms were also given to their parents/guardians to complete. In addition to this a privacy notice was also issued. The PLS’s and consent forms all detailed the purpose of the research and what would be involved during the data gathering phase, the details of the research were as full as possible to allow for fully informed consent to be given (Malone, 2003). It also made clear that students could opt out at any time or refuse to answer any question. A clear statement of how withdrawal would not affect their participation in the projects or have any influence on grades obtained was included in the PLS’s and consent forms. All PLS’s, consent forms and data protection has been included as Appendix C.

For the completion of the questionnaires no consent forms were required as the questionnaires were completely anonymous. Completion of the questionnaire was deemed to be implied consent for the use of the data obtained in this research project. When questionnaires were handed out it was made very clear that they did not have to answer any questions or complete the questionnaire at all if they did not wish to.

In a position of power such as in the student-teacher relationship gaining consent must be done without exerting any influence over the participants free will to maintain the integrity of the research conducted. All professional codes of conduct must be followed, these being put in place to not only protect the young people involved in research but also the researcher (Cohen, Manion and Morrison*,* 2018). The researcher is also responsible for ensuring that privacy and personal freedom are not impacted by their research, this should be dealt with through the design of the research methodology with the overarching idea of ‘do no harm’ being at the forefront of all that they do (Hammersly, 2021)

**3.8 Summary**

The data gathered, both quantitative and qualitative, was extensive. It must be considered that the data gathered from interviews was limited to those that chose to take part and only shows the personal views and opinions of those students who were more engaged and enthusiastic about the projects to begin with. The data, also, only shows the views of the S2 pupils participating and may not be representative of the entire S2 cohort and, due to the limited context of the study cannot be generalised to other schools and settings. However, the growing importance of STEM education and the importance of STEM to continued economic growth does mean the research should not be disregarded in its entirety when viewed as a model for other contexts. The findings of this data will be discussed in the following chapters.

**Chapter 4: Discussion of Findings**

In this chapter the results of the questionnaire and interviews will be analysed using the methodology discussed in Chapter Three. This analysis will be used to attempt to answer the research questions posed in Chapter One.

Three projects were undertaken, one in a class setting and two as extracurricular projects. Details of the three projects can be found in Appendix D.

**4.1 Questionnaires**

The following finding were obtained by comparing the results from the pre-intervention with the post-intervention questionnaire. The number who completed the pre-intervention questionnaire (60 students) was higher than the number who completed it post-intervention (55 students).

*Table 1:* *What does STEM stand for?*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Correct Answer: Science, Technology, Engineering, Mathematics. | | | Incorrect answer | | |
| Pre-intervention | Post-intervention | Percentage change | Pre-intervention | Post intervention | Percentage change |
| 47 (out of 60) | 47 (out of 55) | +7% | 13 (out of 60) | 8 (out of 55) | -7% |

Table 1 shows that post-intervention there was an increase in understanding of what the acronym stands for. This does not show an increase in attitude or engagement but understanding what they are involved in is seen as the first step to becoming more engaged.

*Table 2: What 3 words does STEM make you think of?*

|  |  |  |  |
| --- | --- | --- | --- |
| Pre-intervention | | Post-intervention | |
| Top Five Responses | Percentage Frequency | Top Five Responses | Percentage Frequency |
| Science | 62% | Science | 53% |
| School | 22% | Experiments | 29% |
| Technology | 17% | Maths | 24% |
| Experiments | 15% | Education/Technology/Work | 18% |
| Smart/Work | 12% | Smart | 16% |

Respondents were asked to write down the first three words that come to their mind when they think about STEM. This allows their ideas about what STEM means to them to be understood. Table 2 shows the top answer given both pre- and post-intervention is ‘Science’. This is not surprising as this is the first word represented by the STEM acronym and the department through which the research was conducted. Interestingly, while almost a quarter of respondents in the pre-intervention questionnaire wrote ‘School’ this was not in the top 5 responses post-intervention. This could be due to more exposure to STEM in non-school contexts through the projects. The use of ‘Experiments’ nearly double as a response from pre- to post intervention, again this could be due to the exposure to working out real-life solutions to problem that the projects offered. The term ‘Smart ‘appears in both lists, which is not positive to see as it suggests a preconceived idea that STEM is only accessible to those who are considered naturally clever.

*Table 3: What is your favourite subject at school?*

|  |  |  |  |
| --- | --- | --- | --- |
| Subject | Percentage of Cohort Pre-intervention | Percentage of Cohort Post-intervention | Percentage Change |
| P. E | 18% | 33% | +15% |
| History | 17% | 24% | +7% |
| Science | 15% | 11% | -4% |
| Drama | 12% | 7% | -5% |
| Art | 10% | 4% | -6% |
| Don’t Know | 7% | 0% | -7% |
| Music | 5% | 5% | 0 |
| Modern Studies | 5% | 7% | +2% |
| English | 5% | 0% | -5% |
| Maths | 3% | 2% | -1% |
| Computer Science | 2% | 2% | 0 |
| Technical | 2% | 2% | 0 |

Table 3 shows that for the STEM based subject both Science and Maths decreased in popularity post-intervention. This can be due to several factors such as differences in the composition of the post-intervention group, although with only 5 fewer responses it is unlikely this has made a large impact. It could also be due to new strategies being implemented in other subjects, such as P.E and History, increasing their popularity external to anything happening in the STEM subjects. The third option is simply that students were enjoying Science and Maths less which may have been due to the projects they were involved with or the content of the normal learning within the subjects.

*Table 4: Likert-style responses to question 4 to 9 (Scale of 1(Not at all) to 10 (Very much))*

|  |  |  |
| --- | --- | --- |
|  | Pre-intervention Average | Post-intervention average |
| Question 4: I enjoy Science | 7.1 | 6.9 |
| Question 5: I enjoy Technology | 6.5 | 5.3 |
| Question 6: I enjoy Maths | 5.9 | 5.5 |
| Question 7: I understand why it is important for everyone to learn Science | 8.2 | 7.5 |
| Question 8: I understand why it is important for everyone to learn Technology | 6.9 | 6.2 |
| Question 9: I understand why it is important for everyone to learn Maths | 9.1 | 8.8 |

These six questions provide a lot of information about the perceptions of the STEM subjects. While the enjoyment of Science and Maths did not change markedly from the pre- to post intervention questionnaire, Technology did decrease considerably. This could be attributed to something that was happening within that subject, such as a move away from more hands-on work to more theoretical or design work. Interestingly, while maths was obviously the least popular of the three subjects as far as enjoyment goes there was a clear understanding of how important a subject it is to learn. Science was the only subject to see a notable decrease from pre-to post-intervention for importance. This may have been due to the projects encouraging more use of Maths and technical skills to solve the problems presented, especially in the extracurricular projects.

*Table 5: What subject have you chosen for S3?*

|  |  |
| --- | --- |
| Number of STEM subjects chosen | Number of Students |
| 0 | 4 |
| 1 | 15 |
| 2 | 29 |
| 3 | 12 |

The information for this question was only looked at pre-intervention, due to pupils’ subject choices being submitted before the projects began it will not have changed over the course of the research. This information allows the number of STEM subjects being taken by each pupil to be recorded. Only four out of the 60 respondents are not taking any STEM subjects at all with nearly half taking two. This is positive to see as it shows that the vast majority will be continuing their studies in STEM to at least a National level and, hopefully, beyond into advanced courses and further/higher education.

*Table 6: What job/sector would you like to work in when you leave school?*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Requires STEM | | | Does Not Require STEM | | | Don’t Know | | |
| Pre-intervention | Post-intervention | Percentage change | Pre-intervention | Post-intervention | Percentage Change | Pre-intervention | Post-intervention | Percentage Change |
| 32 | 33 | +7% | 22 | 15 | -10% | 6 | 7 | +3% |

While there was a slight increase in pupils who were unsure of what they wanted to do when they leave school there was a larger increase in the percentage of respondents who wanted to work in a STEM or STEM linked industries. This question does not show if the pupils understand whether the job they would like to do is a STEM job or not.

*Tables 7 & 8: Do you plan to go to college/university after school? & If yes, what would you like to study?*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Yes | | | No | | |
| Pre-intervention | Post-intervention | Percentage Change | Pre-intervention | Post-intervention | Percentage Change |
| 54 | 52 | +5% | 6 | 3 | -5% |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| STEM | | | Non-STEM | | | Don’t Know | | |
| Pre-intervention | Post-intervention | Percentage Change | Pre-intervention | Post-intervention | Percentage Change | Pre-intervention | Post-intervention | Percentage Change |
| 27 | 26 | +2% | 16 | 17 | +4% | 11 | 9 | -2% |

Tables 7 and 8 show the plans pupils have for their further/higher education. Most of the pupils’ plan on continuing their education onto either college or university. Post-intervention saw more students plan to go on to college or university, with a 5% increase. Non-STEM fields saw a larger increase in interest post-intervention compared to STEM fields.

*Table 9: Do you think your future career will need/include STEM?*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Yes | | | No | | |
| Pre-intervention | Post-intervention | Percentage Change | Pre-intervention | Post-intervention | Percentage Change |
| 45 | 41 | 0 | 15 | 14 | 0 |

This question looked at the students understanding of STEM and how it may relate to their future career plans. The percentage who believes STEM will be a part of their future career did not change from pre-intervention to post-intervention.

The next section on the questionnaire asked pupils to imagine someone who works in STEM comes to speak to their class*.* They were then asked to describe different aspects of them such as how they look and what sort of job they do. Details of the coding used can be found in Appendix E

*Table 10: Describe what the person looks like.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Number of Words Used Pre-intervention | Frequency Per Person | Number of Words Used Post-intervention | Frequency Per Person |
| Positive Descriptions (including non-stereotypical descriptions) | 75 | 1.25 | 65 | 1.18 |
| Negative Descriptions (including stereotypical descriptions | 87 | 1.45 | 80 | 1.45 |
| Neutral Descriptions | 44 | 0.74 | 24 | 0.44 |

The frequency of positive or non-stereotypical language used was 1.25 words per respondent in the pre-intervention questionnaire. While this did drop post-intervention to 1.18 words per respondent it was not a significant drop. The frequency of negative and stereotypical descriptions stayed constant from pre- to post-intervention, it was also higher than positive descriptions in both questionnaires. This shows that despite taking part in the project’s students continued to hold more negative and stereotypical views in relation to people who work in STEM. This could be due to a lack of diverse role models being presented in the projects.

*Table 11: What sort of job do they do?*

|  |  |  |  |
| --- | --- | --- | --- |
| Sector | Pre-intervention | Post-intervention | Change in Percentage Frequency |
| Science | 23 | 30 | +16.2% |
| Technology | 4 | 4 | +0.6% |
| Engineering | 13 | 6 | -10.8% |
| Maths | 2 | 1 | +0.3% |
| Medicine | 11 | 4 | -11.1% |
| Education | 9 | 11 | +5% |
| Other STEM | 3 | 2 | -1.4% |
| Other | 0 | 6 | +10.9% |
| Don’t Know | 0 | 7 | +12.7% |

The science sector was the most common answer to this question, increasing quite greatly post-intervention. This may be due to the projects being run through the science department, this may also account for the decrease in the other STEM based answers. Education also saw an increase, although smaller at 5%. Again, this could be attributed to the delivery of the projects by teachers with only one project having anyone outside of education involved in the process, The only other sectors that saw a significant increase in answers were ‘Other’ (non-STEM related jobs) and ‘Don’t Know’. Due to no one answering ‘Don’t Know’ in the first questionnaire it can be assumed that it is unlikely that this is a genuine answer and more likely attributed to not wanting to complete the question.

*Table 12: How did they get to do that job?*

|  |  |  |  |
| --- | --- | --- | --- |
| Reason | Pre-intervention | Post-intervention | Change in Percentage Frequency |
| Further/Higher Education | 27 | 23 | -3.2% |
| Hard Work | 23 | 22 | +1.7% |
| School/Education | 11 | 3 | -12.8% |
| Qualifications | 11 | 7 | -5.6% |
| Personal Interest | 8 | 7 | -0.6% |
| Applied for Position | 7 | 1 | -9.9% |
| Don’t Know | 5 | 9 | +8.1 |
| Smart/Natural Ability | 3 | 3 | +0.5% |

The most popular concept for how someone gets their job in STEM is still that you must go to college or university. It was unfortunate to see a reduction in the belief that a school education would be enough. On a positive note, ‘Hard Work’ was viewed highly for how someone got to do their job. This shows that most students do not believe the stereotypical view that only those with natural ability can study or working in STEM. Again, we see an increase in ‘Don’t Know’ being answered. This could again be attributed to a desire to not answer the question.

*Table 13: What kind of people have careers in STEM?*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Question | Options | Pre-intervention Percentage Frequency (%) | Post-intervention Percentage Frequency (%) | Change in Percentage Frequency (%) |
| 1. How well did they do in school? | Only Get A grades | 65 | 60 | -5 |
|  | Gets a mix grade | 55 | 60 | +5 |
| 1. What kind of economic background do they come from? | Upper class | 50 | 51 | +1 |
|  | Middle class | 73 | 69 | -4 |
|  | Working class | 45 | 47 | +2 |
| 1. What is their gender? | Male | 85 | 78 | -7 |
|  | Female | 58 | 56 | -2 |
|  | Other | 33 | 40 | +7 |
| 1. What kind of ethnic background do they come from? | Asian or Asian British | 62 | 64 | +2 |
|  | Black, Black British, Caribbean, or African | 53 | 51 | -2 |
|  | Mixed or multiple ethnic groups | 62 | 64 | +2 |
|  | White | 87 | 76 | -11 |
|  | Other ethnic group | 47 | 49 | +2 |
| 1. What level of education do they have? | Went to university | 90 | 85 | -5 |
|  | Went to college | 55 | 55 | 0 |
|  | Only went to secondary school | 13 | 29 | +16 |
| 1. What is their sexuality? | Heterosexual (Straight) | 88 | 85 | -3 |
|  | Homosexual | 48 | 49 | +1 |
|  | Bisexual | 45 | 55 | +10 |
|  | Other | 43 | 49 | +6 |
| 1. Do they have a disability? | Has a visible disability | 48 | 45 | -3 |
|  | Has an invisible disability | 62 | 55 | -7 |
|  | Has no disability | 92 | 89 | -3 |

These questions were used to show whether the students held stereotypical views of who works in STEM and if they view certain characteristics as barriers to working in STEM. They were able to select as many answers as the felt appropriate. Overall, an increase the frequency of an answer selected would be seen as positive as this would show that they did not feel that any group was excluded for STEM, although a reduction in the stereotypical views would not be seen as negative. From table 13 it was positive to see that there was an increase in frequency of selection of those that ‘get mixed/lower grades’ as this shows that there is an increased acceptance that natural ability or being ‘smart’ is not required to have a career in STEM. This links to the results from table 12 that showed that ‘Hard Work’ was seen as a route into a career in STEM. There was also an increase in the selection of non-stereotypical options for economic background, gender, ethnic background, education, and sexuality. These are all positive to see as it shows that more students do not believe these to be a barrier to STEM after participating in the projects. The decrease in selection for all options in ‘Do they have a disability?’ was, however, disappointing. With school becoming ever more inclusive and more young people with visible and invisible disabilities in mainstream education it would have been hoped that most people no longer viewed this as a barrier to pursuing the career of their choosing.

*Table 14: Why do you think people DON’T wasn’t to work in STEM?*

|  |  |  |  |
| --- | --- | --- | --- |
| Option | Pre-intervention Percentage Frequency (%) | Post-intervention Percentage Frequency (%) | Change in Percentage Frequency (%) |
| Too difficult | 80 | 76 | -4 |
| Not smart enough | 63 | 56 | -7 |
| Not exciting | 40 | 47 | +7 |
| Have to write too much | 42 | 56 | +14 |
| Don’t make enough money | 35 | 36 | +1 |
| Not interesting | 50 | 51 | +1 |
| Have to go to university | 45 | 55 | +10 |
| No jobs available | 47 | 47 | 0 |
| Stuck in a lab | 43 | 44 | +1 |

Table 14 shows the attitudes towards why people would not want to work in the sector. Post-intervention the reduction in ‘Too difficult’ and ‘Not smart enough’ are positive as, in agreement with the results from tables 12 and 13, it shows there is not a belief that STEM is only for those with naturally ability. It is interesting to note that nearly half of respondents believe that there are not suitable jobs available for those who wish to work in STEM and just over a third do not think STEM jobs pay well. This is in contradiction to the data from the Scottish government and around the world that STEM is the fastest growing industry with demand for qualified workers only set to increase. This shows a lack of understanding in students regarding the employment opportunities available to them when they leave school, which may be a failing in how careers advice is being delivered within the school. The excitement, interest and writing aspects are things that can be looked at in how the normal curriculum is delivered, it may be that activities are not linked to suitable real-life examples which are more likely to hold students’ interest.

**4.2 Interviews**

Seven interviews were conducted with students from all projects. Their responses to the five questions (which can be found in Appendix B) were recorded Ver Batum with no amendments to wording made.

When asked what they liked about STEM all the interviewees were very positive and spoke about what it can provide them that for the future. Responses such as those below show this:

“Job opportunities.”

“Employment. Applies to good stuff, picking up skills.”

“Experience. Trying something different, opportunities.”

It also became apparent that they saw STEM as a means to build relationships with others through working collaboratively:

“Friendship, hard work, people.”

“Working with others.”

And ultimately a way to gain interesting knowledge:

“Interesting and fun. Makes you smarter if you actually listen to it.”

“Fun way to learn science. More Creative, finding more skills.”

The reasons given for why they dislike STEM and STEM education show the same results as the questionnaires with a dislike of Technology as a school subject and the challenging nature of STEM being cited. The other reason given was not to do with the actual content of STEM education but with the curriculum. They felt that not enough focus was placed on STEM, and this was affecting their enjoyment. This may be due to feeling like topics are not covered in enough depth or not enough time is spent allowing for student-led enquiry.

“Sometime difficult to understand.”

“Tech because it’s boring.”

“Not enough time/focus.”

“Would like more time spent in STEM.”

All the interviewees were enthusiastic about the projects that they participated in. Everyone felt they had gained several skills, the most prominent among these being teamwork. Working as a team and the collaborative aspect of the projects was very popular and something that they felt improved their work. They felt they came up with more ideas when collaborating rather than working independently. STEM occupations are inherently about collaboration, sharing of ideas and working together to find a solution. Therefore, finding this the aspect of collaboration to be such a positive one is encouraging and may make them more open to look at a future career in STEM. There was also an understanding, again, of the skills that it has helped them develop and what it can do for their future. Perhaps the most positive aspects mentioned, give the aims of this research, was that it allowed them to find role models to look up to. Identifying role models will allow students to aspire to emulate that person, it can also provide them with someone who can potentially offer them guidance as they progress through their education and into a career.

“Working as a team, collaborating to come up with new ideas.”

“Meet new people. Work in a group you might not normally work with.”

“Getting ideas from others, collaboration. Group work improves socialisation and confidence.”

“Find out about new areas of interest. People to look up to. New job options not heard of before.”

The negative aspects of the projects were the same as why they enjoyed it, teamwork. Working as a team can bring about wonderful ideas through collaboration but to get there requires discussion. Sometimes discussion and disagreement can result in arguments. While the interviewees viewed this negatively, and actual arguments are negative, it can also be viewed positively as learning how to move past disagreements, compromise, and listen to others are all important skills to learn not only for STEM but life. Working as a team everyone must ensure they are doing their bit and learning how to discuss the fair sharing of tasks is a skill that is important skill to learn.

“Decisions being made without everyone. Judgy - some members not taking part.”

“Arguments.”

“Some group members not pulling their weight.”

“Some group members not engaging. Better time management.”

Some interviewees also expressed their disappointment that they didn’t feel that they were able to see the projects through to the natural conclusion. For two of the extracurricular groups the end point of the project was at the end of the planning stage. This was due to the Industrial Cadets projects naturally finishing at that point, the groups however would have liked to have been able to implement their plans in real life. For the class-based projects the launch of the balloon was delayed, and the experiments were not returned until after the end of term.

“Miss the actual practical part of planting flowers.”

“Didn’t get to see it through.”

The final part of the interview was to find out whether they saw their future career in STEM. Six of the seven interviewees said they did. The seventh interviewee would like to be an actor. This was positive but it is not possible to know if they have changed what they would like to do as a career due to the projects or if this was what they have always wanted to do.

**Chapter 5: Conclusion and Recommendations**

This research looked to identify the role that promotion of STEM projects has on pupils’ engagement and attitudes towards STEM education and possible future careers in STEM. In this chapter the findings from Chapter Four will be related back to the research question in an attempt to answer it. The limitations of the research will also be discussed. This, along with evaluation of the study and how the research will be disseminated, will allow for recommendations to be provided for further study which have been identified.

**5.1 Summary of Discussion and Findings**

The aim of this research was to look at the impact that participation in STEM-based project out with the normal curriculum had on pupils’ attitudes towards STEM and whether presenting STEM to them in a novel manner would change their perception of it. While project work within the STEM subjects, particularly science and technology, is not a new idea it is not something that is used extensively in the BGE phase and, if used, is done so in a limited manner attempting to build on an already full curriculum. The first step was to ascertain whether pupils understood what STEM is. The question of ‘what does STEM?’ mean is still be grappled over by those in charge of education, it would be unsurprising if this confusion had filtered down to the pupils. Overall, the understanding of what the STEM acronym stands for and its broader meaning was good amongst pupils and improved after taking part in the projects. This was positive, although understanding what it means does not equate to enjoyment or engagement. When pupils were asked what their favourite subject was, science was third overall both pre- and post-intervention but dropped in popularity by post-intervention, maths and technology both languished at the bottom of the popularity table both pre- and post-intervention. The top two subjects, P.E and history, both increased in popularity post-intervention taking more than half of the responses between them, the reason for this is unknown but for P.E it may be due to the lack of written work and critical thinking.

When asked to focus on STEM subjects and their enjoyment and importance of them their views became clearer. Of the three STEM subjects taught in school, science is enjoyed most with maths being least popular pre-intervention and technology taking bottom spot post-intervention. The importance of science and maths were well understood which suggest that with the proper motivation they could become more engaged with these subjects. The responses in the interviews showed why great importance is placed on these subjects with job opportunities and future employment cited. The importance of technology was placed quite a bit lower than that of science and maths, which is surprising given the worlds reliance on it, perhaps they take it for granted or do not understand the link between the subject they are taught in school and the real-life applications of it. This was also mirrored in the interview with technology being singled out as a ‘boring’ subject. While the enjoyment and understanding of importance in all three subjects dropped post-intervention it is not possible to say if this was due to the projects or something occurring in the normal curricular learning and teaching.

Increasing enjoyment and attitude in STEM education is ultimately about increasing the numbers who will continue in their STEM education and onto STEM career. While the STEM subjects may have not been very popular most pupils believe that when they leave school, they would like to have a career that involves STEM with most looking to study for a STEM-based qualification at college or university.

From the literature review there are many barriers to engaging with STEM. One of the biggest barriers is the perceptions of stereotypes (for STEM this is usually old, white, and male) and for many, like girls and those from ethnic minorities, they do not see their selves represented in many STEM fields. By asking the pupils to describe someone who works in STEM it was possible to see if they perceived these barriers. Unfortunately, language that was negative or stereotypical was used more frequently both pre- and post-intervention. These views were confirmed by asking them to select all types of people who have careers in STEM. A male, white, university graduate, straight person with no disabilities was the most common answers. While there was a positive move in the frequency of non-stereotypical responses this does suggests that the projects did not allow for these stereotypes to be broken down. This may have been due to a lack of outside engagement from those working in STEM who could have been role models to many of the pupils. One common stereotype that was not a view held by most pupils was that of natural ability. Over a third of those who completed the questionnaire saw hard work as the main route into a career in STEM, but this was tempered by the belief that people wouldn’t work in STEM because it is ‘too difficult’. They seem to understand that hard work can get them there but, perhaps, it is not worth the effort.

One of the more interesting findings in this research came from the data gathered in the interviews. The development of ‘soft’ skills is incredibly important for future employment in any field. Soft skills include critical thinking, problem solving, cooperation and collaboration. When asked about what they enjoyed about the projects all responded with answers around cooperation and collaboration. They were able to develop skills in conflict resolution, listening to others and compromising. These soft skills are often forgotten about in everyday teaching and learning but have proved to be incredibly important for future career opportunities.

**5.2 Key Findings**

The key findings of this research are that while participation in these projects has not had a major impact on pupils’ attitudes towards STEM, it has allowed them to develop skills that they may not have had the opportunities to develop through the normal delivery of the curriculum.

Engagement with outside agencies is also very important. The one project group that did have access to a mentor spoke about what a positive experience that was for them. Having people from diverse backgrounds who work in STEM engage with pupils will allow them to breakdown stereotypes and see STEM as a more approachable sector where they will be welcome and accepted.

**5.3 Limitations of the Study**

As with any social research there will be limitations as to what can be achieved. Issues that can affect the scope with which research can be undertaken will include the researchers time, size of sample set, and the way data is collected.

The limitation in the data collection methods have been discussed previously in the Data collection section (3.4).

As a teacher engaged in research it important to remember that research will be conducted in addition to their normal teaching commitments. It is these teaching commitments that must always take precedence to ensure that there is no decrease in quality of teaching for the students involved in the research, but also for others not involved. The projects taking place during normal class time were carefully planned to add value to their learning experience rather feeling like a departure from it. As the class-based delivery of one of the projects was done by the researcher and two other teachers, time was spent discussing with these teachers what would work for their class and how best to deliver the projects alongside the required curricular teaching. All preparation was done out with the school day by the researcher to not add to other teachers’ workload. All collection of data from the class groups and extracurricular groups was planned to be completed within the allocated project time to reduce any impact on the pupil’s time and to minimise any impact on their learning.

The size of the sampled group, time over which the research was conducted, and composition of the groups will also have an impact on how the results can be used for generalisation. It may not be possible to use the data to determine if the same results would be obtained in a different year group, using different project or in different setting/schools. The influence of the researcher’s relationship with the students cannot be ignored in a different setting where the researcher had no prior relationship with the students the results may be different.

Another major factor that may have impacted the data obtained in this research project is that of timing. Projects were started late in the year and continued up to two weeks before the end of the school year. During this time the S2 cohort moved onto their S3 timetables. This impacted when data could be collected and how many were available for the second data collection. There is also a question of how useful these types of projects would be if conducted so late in the year that S3 subject selections had already occurred. It may be a case of ‘too little, too late’ with attitudes to STEM already being perhaps a little too deep rooted by this point.

**5.4 Evaluation of the Study**

If this research were to be carried out again there are several changes that may wish to be made. The primary among these would be the timing of the projects. Due to planning and selection of projects work on the research could not begin until late in the school year. This meant that pupils were rushed to complete the projects and there was a timetable move before completion. For future research it would be sensible to select projects that started much earlier in the school year and have projects that ran for longer. With a longer running project it would be possible to have more time to introduce pupils to people outside of education who could be role models for them and give them a more realistic insight into STEM. Starting the projects earlier and running them for longer would also allow for more time to conduct questionnaires and interviews with a greater number of pupils. A longer timescale would allow for interviews to be conducted at different points throughout the research giving a more rounded view of pupil’s attitudes rather than just at the end. Due to the late starting time of the project’s pupils had already selected their subjects for S3, starting the research earlier in the school year would show if there was an impact on subject choices from participation.

The class-based projects were conducted with three of the seven S2 science classes. For future research it would be useful to engage a larger proportion of the S2 to get a clearer view of the attitudes held by the cohort and allow for more generalisation of the findings.

**5.5 Conclusion**

The aim of this research was to look at the impact targeted promotion of STEM opportunities has on the attitudes of pupils towards STEM. By introducing non-curricular based projects, it looked to understand what drives pupils’ motivation and desire to study STEM subject beyond the BGE level. The findings of this research shows that while the introduction of projects increases an understanding of what STEM is and helped to remove some of the barrier’s pupils perceive to studying STEM-based subjects it did not positively change their overall attitude towards STEM with a decrease in enjoyment and understanding of importance of STEM subjects reported over the course of the study. It was found that skills associated with STEM education, particularly teamwork, were developed through project work. This development of soft skills is very important for preparing pupils for the future in further education or work and the use of project-based learning should be looked at as a tool to help in this development. The results of this study were based on a small sample size, and it must be noted that it would be advantageous to look at the use of project-based learning on a much larger scale and over a longer period.

STEM-based industries are growing rapidly as is the use of science and technology in our everyday lives. It is imperative that education properly prepares pupils for life outside of school therefore the development of new strategies for STEM education must be a priority. Only through a solid STEM education will young people be able to contribute effectively to the future of their communities and the wider world and prepare their selves to be successful in their future employment.

**5.6 Dissemination**

The results of this research will be disseminated to stakeholders. The head of the school science department has been pivotal in assisting with this research, not only delivering one of the class-based projects but also providing support and interest on a personal level to the research to be conducted. He is, therefore, keen to review the findings of this research and the implications it could have for the delivery of BGE science in the department. To the wider science department, findings will disseminate and discussed at a department meeting to allow all involved in the delivery of BGE science to have an input into how, if at all, they would wish to take this research further as a department through implementation or gathering of additional data. The findings will also be presented to the senior leader in the school where discussions around how this research may apply to the whole school and whole school policy will be held.

**5.7 Recommendations**

In addition to the size and scope of this research being very small the projects were run for a very short amount of time. Further research on the impact of projects could be done which included the whole of the S2 cohort and perhaps the S1 BGE science classes as well. Having a larger sample size would give more reliable results as to the true impact of these projects. In addition to this the projects could be started earlier in the school year and run for longer. This would allow teachers and pupils to become more familiar with the process which could allow them to gain more from the experience.

The projects that were used would need to be carefully selected to ensure they fulfil the requirements of allowing the pupils to develop skills while complementing the curricular learning. A bank of projects should be established which can be selected from and contacts, who can support the pupils throughout the project, identified. Projects should allow pupils to engage with STEM in a more authentic manner, mirroring what it would be like to work within STEM in the real world. Through careful selection of projects, it is possible to build them into the curriculum and allow them to aid in the delivery of the required teaching and learning. This will allow for the development of necessary soft skills as the learn. Basing the projects in class time as well will allow those who may have other barriers to engagement such as time constraints and a lack of money to participate fully.

During the last few years interaction with outside agencies such as universities and industry has been minimal. Now a concerted effort must be made to re-establish networks and develop connections that aid in the delivery of projects and provide pupils with diverse role models that they can look up to and seek to emulate.

**Appendices**

**Appendix A**

**Logo

Description automatically generated Survey**

**Section 1**

1. What does STEM stand for?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What three words does STEM make you think of?
   1. A picture containing clipart

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   2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What is your favourite subject at school?

A picture containing clipart

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1. I enjoy science (Circle the number)

*Not at all Very Much*

1 2 3 4 5 6 7 8 9 10

1. I enjoy technology (Circle the number)

*Not at all Very Much*

A drawing of a pair of scissors

Description automatically generated with low confidence 1 2 3 4 5 6 7 8 9 10

1. *A picture containing clipart

   Description automatically generated*I enjoy maths. (Circle the number)

*Not at all Very Much*

1 2 3 4 5 6 7 8 9 10

1. I understand why it is important for everyone to learn science. (Circle the number)

*Not at all Very Much*

1 2 3 4 5 6 7 8 9 10

1. I understand why it important for everyone to learn technology. (Circle the number)

*Not at all Very Much*

1 2 3 4 5 6 7 8 9 10

1. I understand why it is important for everyone to learn maths. (Circle the number)

*Not at all Very Much*

1 2 3 4 5 6 7 8 9 10

1. What subjects have you chosen for S3

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

A picture containing text, clipart

Description automatically generated\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**A group of people in garment

Description automatically generated with low confidenceSection 2**

1. What job/sector would you like to work in when you leave school?

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1. Do you plan to go to college/university after school? (Tick one)

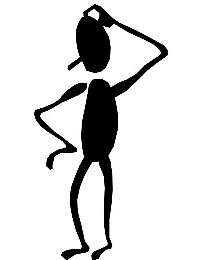
Yes □ No □

If yes, what would you like to study?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Do you think your future career will need/include STEM?

Yes □ No □

1. Imagine someone who works in STEM comes to speak to your class.

Describe what that person looks like:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

A black and white sign

Description automatically generated with low confidenceWhat sort of job do they do?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

A picture containing text, clipart

Description automatically generatedHow did they get to do that job?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What kind of people have careers in STEM? (Tick all that you think are true)
   1. How well did they do in school?

Only gets A grades □

Gets a mix/lower grades □

* 1. What kind of economic background do they come from?

Upper class □ Middle class □ Working class □

* 1. What is their gender?

Male □ Female □ Other □

* 1. What kind of ethnic background do they come from?

Asian or Asian British □

Black, Black British, Caribbean or African □

Mixed or multiple ethnic groups □

White □

Other ethnic group □

* 1. What level of education do they have?

Went to university □

Went to college □

Only went to secondary school □

* 1. What is their sexuality?

Heterosexual (straight) □

Homosexual □

Bisexual □

Other □

* 1. Do they have a disability?

Has a visible disability (These are disabilities you can see when you look at the person. They may use a wheelchair or walking aid, have a guide dog or use sign language to communicate.) □

Has an invisible disability (These are disabilities you wouldn’t know a person had just by looking at them. These include chronic pain, Crohn’s disease, diabetes, and mental health problems) □

Has no disability □

1. Why do you think people DON’T want to work in STEM? (Tick all that apply)

Too difficult □

Not smart enough □

Not exciting □

Have to write too much □

Don’t make enough money □

Not interesting □

Have to go to university □

No jobs available □

Stuck in a lab □

A picture containing text, clipart

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**Appendix B**

**What impact does targeted promotion of STEM opportunities have on student perception of STEM?**

**Interview Schedule**

One interview will be conducted on conclusion of the project.

Interviews will be conducted one-to-one.

Interviews will cover the same questions each time and responses will be recorded in writing by the interviewer.

Questions

1. What do you like about STEM?
2. What don’t you like about STEM?
3. What do you like about this project?
4. What don’t you like about this project?
5. Do you think you would like to work in a STEM job?

**Appendix C**



**Plain Language Statement**

**Parents / Carers / Guardians**

**What impact does targeted promotion of STEM opportunities have on student perception of STEM?**

Researcher: Ms Kimberley Gillanders

Supervisor: Ms Julie Shaughnessy

Course: Professional Practice in Education

You child is being invited to take part in a research project to look at whether participation in specific STEM projects changes how they see Science, Technology, Engineering and Maths (STEM) and their participation in it.

Before you decide if you want your child to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the information on this page carefully and discuss it with others if you wish. Ask me if there is anything that is not clear or if you would like more information. Take time to decide whether you wish your child to take part.

I hope that this sheet will answer any questions you have about the study.

**1. What is the purpose of the study?**

The purpose of this study is to find out if children can be encouraged to look at STEM subjects, and possible future STEM careers, in a more positive way.

**2. Why has my child been chosen?**

Your child is being asked to participate as part of a random selection of pupil throughout the classes taking part in STEM projects. These pupils will give their views on the project they are taking part in and on STEM.

**3. Does my child have to take part?**

Your child does not have to take part in this study. If you decide that they should not take part, or if your child does not want to take part, they will still participate in the class project as they are now. If, after your child has started to take part, you or they change your mind, just let me know and I will not use any information they have given me in my writing.

**4. What will happen to my child if they take part?**

If your child takes part, I will ask them some questions about what they think about the project they are taking part in and what they think about STEM. They do not have to answer any questions that they do not want to. This will take about 5 – 10 minutes to complete. I will take a written record of what is said so that I can review the information at a later time.

I will be finished gathering data by 17/06/2022

**5. Will the information that my child gives you in this study be kept confidential?**

I will keep all the data I collect in a locked cabinet or in a locked file on my computer. When I write about what I have found, your child’s name will not be mentioned. A pseudonym will be assigned (this will be in the form of a number) which I will use when writing up the final assignment.

**6. What will happen to the results of this study**

I will analyse the data I collect from the children and present this in the dissertation which I am writing for my qualification, Masters in professional practice (Education). Children who have participated, and their parents, will receive a written summary of the findings and I will also present the information to colleagues. I will destroy the data at the end of the project.

**7. Who has reviewed the study?**

This study has been reviewed and agreed by the School of Education Ethics Forum, University of Glasgow

**8. Who can I contact for further Information?**

If you have any questions about this study, you can ask me, Ms Kimberley Gillanders (2331083g@student.gla.ac.uk)

or my supervisor, Ms Julie Shaughnessy (Julie.shaughnessy@glasgow.ac.uk)

or the Ethics officer for the School of education Paul Lynch (paul.lynch@glasgow.ac.uk)

Thank you for reading this.

A picture containing floor, indoor

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**Plain Language Statement**

**(pupils / children)**

**What impact does targeted promotion of STEM opportunities have on student perception of STEM?**

Researcher: Ms Kimberley Gillanders

Supervisor: Mrs Julie Shaughnessy

Course: Professional Practice

You are being invited to take part in a research project into what students think of Science, Technology, Engineer, and Maths (STEM) and what would make you more interested in it. A research project is a way to learn more about something.

Before you decide if you want to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the information on this page carefully and discuss it with Ms Gillanders and your parents/carers if you wish. Ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

I hope that this sheet will answer any questions you have about the study.

**1. What is the purpose of the study**

The purpose of this study is to find out if we do more STEM projects would students be more positive about STEM and maybe want to do it at university or as a job.

**2. Why have I been chosen?**

You are being asked to take part because I think you will be good at telling me if this is a good or bad idea and also because you are S2 and choosing what subjects you want to do, so will have been thinking about what areas interest you.

**3. Do I have to take part?**

You do not have to take part in this study, and if you decide not to, you will still take part in the projects we are working on. If, after you have started to take part, you change your mind, just let me know and I will not use any information you have given me in my writing.

**4. What will happen to me if I take part?**

If you decide to take part, I will ask you some questions about the project we are working on and STEM in general. You do not have to answer any questions that you don’t want to. This will take about 5 minutes (time). I will record your answers in writing so that afterwards I can read them carefully to what you said.

I will be finished gathering information by 18/06/2022

**5. Will the information that I give you in this study be kept confidential?**

I will keep the information in a locked cabinet or in a locked file on my computer. When I write about what I have found out your name will not be mentioned. If you like you can choose another name for me to use when I am writing about what you said. No-one else will know which name you have chosen.

**6. What will happen to the results of this study**

When I have gathered all of the information from everyone who is taking part, I will write about what I have learned in a dissertation, which is a long essay, which I have to complete for the course I am studying on. This will be read and marked by my teachers at university. I will tell you and the other children who have taken part what I have found out about whether these projects are good or not at making students more positive about STEM. I will destroy all of my notes and recordings when the project is finished.

**7. Who has reviewed the study?**

This study has been reviewed and agreed by the School of Education Ethics Forum, University of Glasgow

**8. Who can I contact for further Information?**

If you have any questions about this study, you can ask me, Ms Kimberley Gillanders (233108g@student.gla.ac.uk)

or my supervisor, Dr Julie Shaughnessy (Julie.shaughnessy@glasgow.ac.uk)

or the Ethics officer for the School of Education

Paul Lynch (paul.lynch@glasgow.ac.uk)

Thank you for reading this.

End. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_



**Consent Form Parent/Carer**

**What impact does targeted promotion of STEM opportunities have on student perception of STEM?**

Name of Researcher: Ms Kimberley Gillanders

Name of Supervisor: Dr Julie Shaughnessy

Iconfirm that I have read and understood the Plain Language Statement for the above study and have had the opportunity to ask questions.

I understand that my child’s participation is voluntary and that they are free to withdraw at any time, without giving any reason.

I Understand that my child will not be named in any way and will be referred to by a pseudonym in any publication arising from the research.

I acknowledge that there will be no effect on my child’s grades through participation in the project.

* All names and other material likely to identify individuals will be anonymised.
* The material will be treated as confidential and kept in secure storage at all times.
* The material will be destroyed once the project is complete.
* I understand that other authenticated researchers will have access to this data only if they agree to preserve the confidentiality of the information as requested in this form.
* I understand that other authenticated researchers may use my words in publications, reports, web pages, and other research outputs, only if they agree to preserve the confidentiality of the information as requested in this form.

I acknowledge the provision of a Privacy Notice in relation to this research project.

**Consent**

I consent / do not consent (delete as applicable) to my child participating in an interview which will be recorded in written form.

I consent / do not consent (delete as applicable) to my child completing a questionnaire about STEM.

I agree / do not agree (delete as applicable) to take part in the above study.

Name of Child ………………………………………………………

Name of Parent//guardian ……………………………………

Signature …………………………………………………….. Date ……………………………………

Name of Researcher ……………………………………Signature ………………………………………

Date ……………………………………



**Consent Form**

**What impact does targeted promotion of STEM opportunities have on student perception of STEM?**

Name of Researcher: Ms K Gillanders

Name of Supervisor: Ms J Saughnessy

**Please tick as appropriate**

Yes No Iconfirm that I have read and understood the Plain Language Statement for the above study and have had the opportunity to ask questions.

Yes No I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

Yes No I consent to a written record of interviews being taken.

Yes No I acknowledge that participants will be referred to by pseudonym.

Yes No I acknowledge that there will be no effect on my grades arising from my participation or non-participation in this research.

**I agree that:**

Yes No All names and other material likely to identify individuals will be anonymised.

Yes No The material will be treated as confidential and kept in secure storage at all times.

Yes No The material will be destroyed once the project is complete.

Yes No I waive my copyright to any data collected as part of this project.

Yes No I acknowledge the provision of a Privacy Notice in relation to this research project.

I agree to take part in this research study

I do not agree to take part in this research study

Name of Participant …………………………………………………………………………

Signature ………………………………………… Date ……………………………………

Name of Researcher ……………………………………Signature ………………………………………

Date ……………………………………

**Privacy Notice for Participation in Research Project:** What impact does targeted promotion of STEM opportunities have on student perception of STEM? Researcher: Ms K Gillanders

**Your Personal Data**

**The University of Glasgow** will be what is known as the ‘Data Controller’ of your personal data processed in relation to your participation in the research project: What impact does targeted promotion of STEM opportunities have on student perception of STEM? This privacy notice will explain how The University of Glasgow will process your personal data.

**Why we need it**

We are collecting answers to a set of interview questions to conduct our research. We need your name to arrange interviews.

We only collect data that we need for the research project and all participants will be anonymous. Pseudonyms will be used in all writing.

Please see accompanying **Participant Information Sheet**,

**Legal basis for processing your data**

We must have a legal basis for processing all personal data. As this processing is for Academic Research we will be relying upon **Task in the Public Interest** in order to process the basic personal data that you provide. For any special categories data collected we will be processing this on the basis that it is **necessary for archiving purposes, scientific or historical research purposes or statistical purposes**

Alongside this, in order to fulfil our ethical obligations, we will ask for your **Consent** to take part in the study Please see accompanying **Consent Form**.

**What we do with it and who we share it with**

All the personal data you submit is processed by: Ms Kimberley Gillanders. In addition, security measures are in place to ensure that your personal data remains safe: All paper work will be kept in a locked cabinet and all digital data will be on a secure server in password protected file. Please consult the **Consent form** and **Participant Information Sheet** which accompanies this notice.

Children who have participated, and their parents, will receive a written summary of the findings and I will also present the information to colleagues. Data will be destroyed at the end of the project.

**What are your rights?\***

GDPR provides that individuals have certain rights including: to request access to, copies of and rectification or erasure of personal data and to object to processing. In addition, data subjects may also have the right to restrict the processing of the personal data and to data portability. You can request access to the information we process about you at any time.

If at any point you believe that the information we process relating to you is incorrect, you can request to see this information and may in some instances request to have it restricted, corrected, or erased. You may also have the right to object to the processing of data and the right to data portability.

Please note that as we are processing your personal data for research purposes, the ability to exercise these rights may vary as there are potentially applicable research exemptions under the GDPR and the Data Protection Act 2018. For more information on these exemptions, please see [UofG Research with personal and special categories of data](https://www.gla.ac.uk/myglasgow/dpfoioffice/a-ztopics/research/#//).

If you wish to exercise any of these rights, please submit your request via the [webform](https://www.gla.ac.uk/myglasgow/dpfoioffice/gdpr/gdprrequests/#d.en.591523) or contact [dp@gla.ac.uk](mailto:dp@gla.ac.uk)

**Complaints**

If you wish to raise a complaint on how we have handled your personal data, you can contact the University Data Protection Officer who will investigate the matter.

Our Data Protection Officer can be contacted at [dataprotectionofficer@glasgow.ac.uk](mailto:dataprotectionofficer@glasgow.ac.uk)

If you are not satisfied with our response or believe we are not processing your personal data in accordance with the law, you can complain to the Information Commissioner’s Office (ICO) <https://ico.org.uk/>

**Who has ethically reviewed the project?**

This project has been ethically approved via the College of Social Sciences Research Ethics Committee or relevant School Ethics Forum in the College.

**How long do we keep it for?**

Your **personal** data will be retained by the University only for as long as is necessary for processing and no longer than the period of ethical approval After this time, personal data will be securely deleted.

Your **research** data will be retained for a period of ten years in line with the University of Glasgow Guidelines. Specific details in relation to research data storage are provided on the Participant Information Sheet and Consent Form which accompany this notice.

End of Privacy Notice \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Appendix D**

**Class-based project**

The Future Martians project run in association with THALES UK, was conducted with three S2 science class. One period per week out of their four science periods was given over to the project and data collection. The students were tasked with coming up with an experiment that would fit inside the plastic capsule from inside a Kinder egg. This would then be sent away where it would be put onto a weather balloon and sent up to the edge of the atmosphere to simulate the conditions on Mars. The aim of this project was to identify the effect of the conditions of Mars that would need to be considered for future Mars colonies. Unfortunately, due to weather conditions the launch of the balloon was delayed. This meant the experiments were not returned in time for the classes to look at the results before the end of the school year.

**Extracurricular projects**

The first was an industry link project run by SSERC and Liedos, an IT solutions company. The group was tasked with designing a party in space. They had to consider the science and engineering aspects of everything they planned and find solutions to any problems they encountered. Once completed a presentation at a showcase event was held where the groups showed what they had made and answered questions about their project. They were also able to speak to the other groups from other schools who were also presenting. Throughout the project they had regular contact with a mentor from the company who visited the school and organised a visit for the group to the Liedos headquarters in Glasgow.

The second was an Industrial Cadets project run by the Engineering Development Trust. Two groups undertook this project which involved the design of a garden with a specific purpose. They were free to choose any type of garden they wished as long as they could show its purpose. They had to produce a scale model and a booklet detailing their project and their roles within the group and what they contributed. They also had to film a five-minute presentation discussing their project. These groups should have had a mentor from industry working with them throughout, but unfortunately do to circumstances out with our control this was not possible.

**Appendix E**

Coding was completed for question 14 of the questionnaire, ‘Imagine someone who works in STEM comes to speak to your class’.

**For question 14 part 1: Describe what that person looks like.**

A large variety of words were used to describe the person. Initially words were split into different aspects of the persons appearance, but this did not allow for the real meaning of the question to be understood. It was then decided that these descriptions should be split into three categories, positive and non-stereotypical; negative and stereotypical; and neutral.

By using these categories, it was possible to see the pupils’ perceptions of what a person who works in STEM looked like. This would reveal if they saw barriers due to holding stereotypical views.

**Negative and stereotypical**

Words that were coded in this category included old, white, male, ugly, and angry.

**Positive and non-stereotypical**

Words that were coded in this category included young, female, trendy, and fun.

**Neutral**

Words that were considered neutral included descriptions of eye and hair colour or hair styles. Colours of clothes were also considered neutral.

**For question 14 part 2: What sort of job do they do?**

The answers for this question were coded into STEM industry categories along with a non-STEM category and an ‘I don’t know’ category.

By coding the responses in this way, it allows for an understanding of what pupils’ view STEM careers as.

**For question 14 part 3: How did they get to do that job?**

Responses were coded into categories for the main theme of the answers given.

For example, ‘Working hard’ and ‘Trying their best and not giving up’ were both placed in the hard work category. While ‘Likes to do it in their own time’ and ‘Enjoy it’ were both placed in the personal interest category.

**REFERENCES**

Akram, O., Maitrot, M., & Denk, T. 2020. Generational bargain, transfer of disadvantages and extreme poverty: A qualitative enquiry from Bangladesh. *The European Journal of Development Research.* **32**: pp.1173-1194

AlAydaroos, F. 2019. How holistic interactive experience can inspire the younger generation through voluntary engagement. *Acta Astronautica.* **161**: pp.363-367

Angier, N. 2010. STEM education has little to do with flowers. *The New York Times.* 04 October Retrieved from <https://www.nytimes.com/2010/10/05/science/05angier.html>. Accessed 21 May 2022

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. 2012. Science aspirations, capital and family habitus: How families shape children’s engagement and identification with science. *American Educational Research Journal.* **49**(5): pp.881-908

Australian Government Department of Education, Employment and Workplace Relations. 2009. *Belonging, Being and Becoming: The Early Years Learning Framework for Australia.* Retrieved from <https://www.dese.gov.au/child-care-package/resources/belonging-being-becoming-early-years-learning-framework-australia>. Accessed 27 Jul 2022

Baeten, M., Dochy, F., & Struyven, K. 2013. The effects of different learning environments on students’ motivation for learning and their achievement. *British Journal of Educational Psychology.* **39**(17): pp.484-501

Baron-Cohen, S. 2003. The essential difference: The truth about the male and female brain. *Phi Kappa Phi forum.* **85**(1): pp.23-26

Baumfield, V., Hall, E. & Wall, K. 2008. *Action Research in the Classroom*. SAGE, London

Bell, J. & Woolner, P. 2012. ‘Academic writing.’ In: Biggs, A. R. J., Coleman, M., & Morrison, M. (ed.) *Research Methods in Educational Leadership & Management.* 3rd ed.London: SAGE publications, pp.266-280

Black, S. E., Muller, C., Spitz-Oener, A., He, Z., Hung, K., & Warren, J. R. 2021. The importance of STEM: High school knowledge, skills and occupations in an era of growing inequality. *Research Policy.* **50**(7): pp.104249

Blanche, M. T., Durrheim, K. & Painter, D. 2007. *Research in practice: Applied methods for the social sciences*. 2nd ed. Juta Legal and Academic Publishers, Cape Town

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. 2012. ‘What is STEM? A discussion about conceptions of STEM in education and partnerships.’ *School of Science and Mathematics.* **112**(1): pp.3-11

Briggs, R.J. 2012. ‘Developing and using questionnaires.’ In: Biggs, A. R. J., Coleman, M., & Morrison, M. (ed.) *Research Methods in Educational Leadership & Management*. 3rd ed. London: SAGE publications. pp.266-280

Brown, J. S., Collins, A., & Duguid, P. 1989. Situated cognition and the culture of learning. *Educational Researcher.* **18**(1): pp.32-42

British Education Research Association (2018) *Ethical Guidelines for Educational Research.* London: BERA

Camilli, G. & Hira, R. 2019. Introduction to special issues – STEM workforce: STEM education and the post-scientific society. *Journal of Science Education and Technology.* **28**(1): pp.1-8

Casad, B. J., Petzel, Z. W., & Ingalls, E. A. 2019. A model of threatening academic environments predicts women STEM majors’ self-esteem and engagement in STEM. *Sex Role.* **80**: pp.469-488

Ceci, S. J. & Williams, W. M. 2010. Sex differences in math-intensive fields. *Current Directions in Psychological Science.***19**(5): pp.275-279

Clark, T., Foster, L., Sloan, L., & Bryman, A. 2021. *Bryman’s Social Research Methods.* 6th ed. University Press: Oxford

Clements, D. H., Vinh, M., Lim, C., & Sarama, J. 2021. STEM for inclusive excellence and equity. *Early Education and Development.* **32**(1): pp.148-171

Clough, M. P. & Olson, J. K. 2016. Connecting science and engineering practices: A cautionary perspective. In Annetta, L. A. & Minogue, J. (Eds), *Connecting Science and Engineering Education Practices in Meaningful Ways: Building Bridges*. Dordrecht: Springer pp.373-385

Cohen, L., Manion, L., & Morrison, K. 2018. *Research Methods in Education.* 8th ed. Routledge: Oxon

De Loof, H., Stuyf, A., Boeve-de Pauw, J., & Van Petegem, P. 2021. Teachers’ motivating style and students’ motivation and engagement in STEM: The Relationship between three key education concepts. *Research in Science Education.* **51**(1): pp.109-127

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. 2019. Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education.* **103**: pp.623-637

Education Scotland. 2015. *Developing the Young Workforce: Career Education Standard (3-18)*. Livingston: Ed Scot

Education Scotland. 2020. *Developing the Young Workforce: Information Update*. Livingston: Ed Scot

Education Scotland. 202.) *Recalibrating Equity and Social Justice in Scottish Education: Bouncing Forward After COVID-19 Lockdowns. Broad Principles*. Livingston: Ed Scot

English, L. D. 2016. STEM education K-12: Perspectives on integration. *International Journal of STEM Education.* **3**:3

Ferrance, E. 2002. *Themes in education: Action research*. *N*ortheast and Islands Regional Educational Laboratory at Brown University: New England

General Teaching Council for Scotland. 2012. *Codes of Professionalism and Conduct.* Edinburgh: GTCS

Görlitz, K. & Gravert, C. 2018. The effect of a high school curriculum reform on university enrolment and the choice of college major. *Education Economics.* **26**(3): pp.321-336

Hafni, R. N., Herman, E., Nurlaelah, E., & Mustikasari, L. 2019. The importance of science, technology, engineering, and mathematics (STEM) education to enhance students’ critical thinking skill in facing the industry 4.0. *Journal of Physics: Conference Series.* **1521**(4): pp.42040-42046

Hambleton, R.K. 2017. ‘Measurements and Validity.’ In: Coe, R., Waring, M., Hedges, L. V., & Arthur, J. (ed.) *Research Methods and Methodologies in Education.* 2nd ed.London: SAGE publications. pp.234-240

Hammersley, M. 2021. ‘Research Ethics.’ In: Coe, R., Waring, M., Hedges, L. V., & Arthur, J. (ed.) *Research Methods and Methodologies in Education*. 3rd ed. London: SAGE publications. pp.56-67

Hibberts, M. F. & Burke Johnson, R. 2012. ‘Surveys and Sampling.’ In: Biggs, A. R. J., Coleman, M., & Morrison, M. (ed*.) Research Methods in Educational Leadership & Management*. 3rd ed. London: SAGE publications. pp.122-139

Hopkins, D.S. (2008) A teachers Guide to Classroom Research. 4th ed. Maidenhead: Open University Press

John, M. S., Sibuma, B., Wunnava, S., Anggoro, F., & Dubosarsky, M. 2018. An iterative participatory approach to developing an early childhood problem-based STEM curriculum. *European Journal of STEM Education.* **3**(3)

Kao, G. & Thompson, J. 2003. Racial and ethnic stratification in educational achievement and attainment. *Annual review of sociology.* **29**(1): pp.417-442

Kelley, T. R. & Knowles, J. G. 2016. A conceptual framework for integrated STEM education. *International* *Journal of STEM Education.***3**(1): Art 11

Kermani, H. & Aldemir, J. 2015. Preparing children for success: Integrated science, math and technology in early childhood classroom.  *Early Child Development and Care.* **185**(9): pp.1504-1527

Khan, A. & Kashif, N. 2020. Secondary school teachers’ perception on STEM integrated education: A analysis. *Review of Economics and Development Studies.***6**(2): pp.485-492

Li, Y., Wang, K., Xiao, Y., & Froyd, J. E. 2020. Research and trends in STEM Education: A Systematic Review of Journal Publications. *International Journal of STEM Education.* **7**(11)

Lobov, J. B., Reid, A. H., & Yamamoto, K. R. 2010. Integrated biology and undergraduate science education: A new biology education for the Twenty-First Century? *CBE Life Science Education.* **9**: pp.10-1

Malone, S. 2003. Ethics at home: Informed consent in your own backyard. *Qualitative Studies in Education.* **16**(6): pp.797-815

Marshall, J. 2011. Images of changing practice through reflective action research. *Journal of Organizational Change Management.* **24**(2): pp.244-256

McComas, W. F & Burgin, S. R. 2020. A critique of “STEM” education. *Science and Education.* **29**: pp.805-829

McKinney, S., Hall, S., Lowden, K., McClung, M., & Cameron, L. 2013. Supporting school leavers in areas of deprivation into initial positive leaver destinations. *Improving Schools.* **16(**1): pp.67-83

Mears, C. L. 2021. ‘In-depth Interviews.’ In: Coe, R., Waring, M., Hedges, L. V., & Arthur, J. (ed.) *Research Methods and Methodologies in Education.* 3rd ed.London: SAGE publications. pp.232 - 239

Mills, G. E. & Butroyd, R. 2014. *Action Research: A Guide for the Teacher Researcher*. Pearsons, Harlow

Moore, T., Stohlmann, M., Wang, H., Tank, K., Glancy, A., & Roehrig, G. 2014. Implementation and integration of engineering in K-12 STEM education. In Purzer, S., Strobel, J., & Cardella, M. (Eds.), *Engineering in Pre-College Settings: Synthesizing Research, Policy and Prac*tices. West Lafayette: Purdue University Press. pp.35-60

Muijs, D. 2004. *Doing Quantitative Research in Education with SPSS*. Sage, London

Munn-Giddings, C. 2021. ‘Action Research.’ In: Coe, R., Waring, M., Hedges, L. V., & Arthur, J. (ed.) *Research Methods and Methodologies in Education*. 3rd ed. London: SAGE publications. pp.85-92

Museus, S. D., Palmer, R. T., Davis, R. J., & Maramba, D. C. 2011. Special issues: Racial and ethnic minority students’ success in STEM education. *Review of Higher Education.* **26**(4): pp.551-552

Navy, S. L., Kaya, F., Boone, B., Brewster, C., Calvelage, K., Ferdous, T., Hood, E., Sass, L., & Zimmerman, M. 2020. “Beyond an acronym, STEM is…”: Perceptions of STEM. *School Science and Mathematics Association*. **121**: pp.36-45

Ng, C. H. & Adnan, M. 2018. Integrating STEM education through project-based inquiry learning (PIL) in topic space among year one pupils. *The Consortium of Asia-Pacific Education Universities (CAPEU). IOP Conf. Series: Materials Science and Engineering.* **296**

Pleasants, J., Vlough, M. P., Olsen, J. K., & Miller, G. 2019. Fundamental issues regarding the nature of technology: Implications for STEM education. *Science and Education.* **28**: pp.561-597

Punch, K. & Oancea, A. 2014. *Introduction to research methods in education*. 2nd ed. SAGE Publications, London.

Putnam, R. & Borko, H. 2000. What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher.* **29**(1): pp.4-15

Sanders, M. 2009. ‘STEM, STEM education, STEMmania.’ *The Technology Teacher.* **68**(4): pp.20-26

Sottish Government. 2014. *Developing the Young Workforce. Scotland’s Youth Employment Strategy: Implementing the Recommendations of the Commission for Developing Scotland’s Young Workfor*ce. Edinburgh: Scot Gov

Scottish Government. 2017a. *Science Technology Engineering Mathematics – Education and Training Strategy for Scotlan*d. Edinburgh: Scot Gov

Scottish Government. 2017b. *Science, Technology, Engineering and Mathematics (STEM) Evidence Ba*se. Edinburgh: Scot Gov

Scottish Government. 2022. *STEM Education and Training Strategy: Refresh*. Edinburgh: Scot Gov

Schmidt, J. A., Beymer, P. N., Rosenberg, J. M., Naftzger, N. N., & Shumow, L. 2020. Experiences, activities, and personal characteristics as predictors of engagement in STEM-focused summer programs. *Journal of Research in Science Teaching.* **57**: pp.1281-1309

Shin, J. E. L., Levy, S. R., & London, B. 2016. Effects of role model exposure on STEM and non-STEM student engagement. *Journal of Applied Social Psychology.* **46**: pp.410-427

Simoncini, K. & Lasen, M. 2018. Ideas about STEM among australian early childhood professionals: How important is STEM in early childhood education? *International Journal of Early Childhood.***50**: pp.353-369

Siregar, Y. E. Y., Rachmadtullah, R., Pohan, N., Rasmitadila, & Zulela, M. S. 2019. The impacts of science, technology, engineering, and mathematics (STEM) on critical thinking in elementary school. *Journal of Physics: Conference Series.* **1175**(1): pp.12156-12160

Struyf, A., De Loof, H., Boeve-de Pauw, J., & Van Petegem, P. 2019. Students’ engagement in different STEM learning environments: Integrated STEM education as promising practice? *International Journal of Science Education.* **41**(10): pp.1387-1407

Townsend, A. 2012. Actio*n Research: The Challenges of Changing and Research Practice.* Open University Press: McGraw-Hill Education, Maidenhead

Tu, T. 2006. Preschool science environment: What is available in a preschool classroom? *Early Childhood Education Journal.* **33**(4): pp.245-251

Tymms, P. 2021. ‘Questionnaires.’ In: Coe, R., Waring, M., Hedges, L. V., & Arthur, J. (ed.) *Research Methods and Methodologies in Education.* 3rd ed.London: SAGE publications. pp.277-288

Van der Vleuten, M., Steinmetz, S., & Werfhorst, H. V. D. 2018. Gender norms and STEM: The importance of friends for stopping leakage from the STEM pipeline. *Educational Research and Evaluation.* **24**(6-7): pp.417-436

Wang, X. 2013. Why students choose STEM Majors: Motivation, high school learning, and postsecondary context of support.  *American Educational Research Journal.* **50**(5): pp.1081-1121

Xie, Y., Fang, M., & Shauman, K. 2015. STEM education. *Annual Review of Sociology.* **41**(1): pp.331-357

Zeidler, D. L. 2016. STEM education: A Deficit framework for the Twenty First Century? A sociocultural socioscientific response.  *Culture Studies of Science Education.* **11**: pp.11-26

Zeidler, D. L., Herman, B. C., Clough, M. P., Olson, J. K., Kahn, S., & Newton, M. 2016. Humanitas Emptor: Reconsidering recent trends and policy in science teacher education. *Journal of Science Teacher Education.* **27**: pp.465-476