Embracing 'science capital': An investigation into the approaches and initiatives established by a post-primary school to promote the uptake of STEM related subjects and subsequently STEM related careers with a particular focus on how this is helping to reduce the gender imbalance

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Abstract
The motivation for my study on the STEM gender imbalance was sparked when I read the statistic that currently in N Ireland "the ratio of males to females employed in STEM-related industries is 3 to 1" (Equality Commission for Northern Ireland, 2015). The insufficient number of females who study STEM (Science, Technology, Engineering and Mathematics) subjects at A-Level through to industry is a highly concerning issue for the future of the N Ireland economy. I believe it is my responsibility as an aspiring post-primary teacher of mathematics and science to promote the uptake of the STEM subjects and careers to the female population for the future success of our economy. I set out to identify the successful strategies being used in one post-primary school and promote those strategies through the creation of a professional development resource to be of use in future practice.

Introduction

Identifying the issue

In preceding years N Ireland has experienced an increasing requirement for skilled workers in STEM based industries for the success of the economy and its ability to compete internationally. Mason (2013, presentation) remarks that "science and technology based companies form the backbone of exports from NI." Nevertheless, many STEM employers are experiencing much difficulty in recruiting and retaining enough staff with adequate levels of STEM qualifications and skills. This has had a negative impact on the economy's ability to attract foreign investment. The Department for Employment and Learning (2012) estimated that there will be 1,000 vacancies per year in the manufacturing and engineering sectors until at least 2020. The success of the N Ireland economy depends on people possessing the skills required to participate in these industries. "Both the Northern Ireland Executive's 'Programme for Government' and the Skills Strategy for Northern Ireland, 'Success through Skills - Transforming Futures', recognise that the future success of the Northern Ireland economy will require increased numbers of skilled workers with science, technology, engineering and mathematics (STEM) qualifications" (STEM Business Group, 2013).

Rationale

Perhaps this shortage of skilled workers is due to the fact that schools are not doing enough to

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encourage, excite and enthuse pupils to study STEM subjects and consider STEM careers. In the whole of the UK, Mason (2013, presentation) urged a target of 830,000 graduate level STEM experts and 450,000 technicians by 2020. Furthermore, he acknowledged a requirement of 100,000 STEM graduates per annum to maintain the status quo. Thus, the motivation for my study in the chosen field is due to the understanding that the insufficient numbers of pupils who study STEM subjects at A-Level through to industry is a highly concerning issue for the future of the N Ireland economy. More specifically, my study will focus on the increased need for females in STEM related careers. Watts (2014, p.42) reiterates the well-known problem that, in Western Europe, women are under-represented in STEM careers with the United Kingdom being one of the worst offenders. Currently in N Ireland "the ratio of males to females employed in STEM-related industries is 3 to 1" (Equality Commission for Northern Ireland, 2015).

'Science capital' refers to the amount of science related qualifications, experience and interest in science a family has and to what extent a child is exposed to an upbringing where science is talked about and seen as important. Stumbling across a research report which stated 'science capital' is key to the promotion of STEM uptake sparked my interest in the idea of 'science capital'. This report from the Department of Education & Professional Studies (2013) acknowledged the huge influence parents and families have on their children's career aspirations. They found that pupils with a low 'science capital' do not express interest in STEM subjects at age 10 and are unlikely to develop STEM aspirations by the age of 14. This provoked me to speculate about the responsibility schools have in encouraging 'science capital' in both pupils and the parents/community. For the purpose of this study, I am going to borrow this term, 'science capital,' and research the importance of embracing it within a school context. Schools have a paramount influence on females when it comes to science, "the culture of school science is the dominant factor in whether pupils choose to study the physical sciences" (Lyons, 2006).

Aims and objectives

Many schools are currently undergoing approaches to increase STEM uptake and interest, however, they may not be aware of this term, 'science capital.' I have chosen to carry out my research in a single sex, female school which has been actively involved in the promotion of STEM. I intend to investigate the strategies implemented in the school that attempt to increase interest and motivation in STEM subjects and careers and understand how these strategies may also be unknowingly increasing 'science capital.' My research will take the form of action research; my main aim is to use the information collected to improve future practice by creating a professional development resource. It is hoped that by raising awareness of this term, 'science capital' that I will provide schools with a focus which will in turn improve the success of these strategies in encouraging uptake of the STEM subjects and careers within the female population.

Literature Review

Introduction

In my literature review, I intend to provide a critical analysis of existing literature which will enable me to determine the current situation regarding the STEM gender imbalance in N Ireland. Walliman (2011, p.55) understands that "when planning a research project, it is essential to know what the current state of knowledge is in your chosen subject…" On completion of my study, I will place it within the existing literature, with the hope that my research provides new evidence and knowledge that can be of use and value in the future.

Understanding the impact of STEM industries for a successful economy

The N Ireland government outlined their view that, "a successful economy is characterised by high productivity, a highly skilled and flexible workforce and employment growth" (Paisley & McGuinness, 2008). A key goal in achieving this vision was, "to increase by 25% the numbers of students, at graduate and postgraduate level studying science, technology, engineering and mathematics (STEM) by 2015" (Paisley & McGuinness, 2008).

It is within the STEM industries of a country that goods and services are created to be sold locally and globally, generating income and attracting foreign investment. Hence, the current campaign to encourage more young people to study STEM subjects to a higher level. Murphy (2008, cited in Fulton, 2014, presentation) suggests that "the downward trend in the number of students that are taking up STEM disciplines is very worrying, as a skills shortage makes it harder to attract new investments here." It is the priority of the government to ensure people have the right skills to deliver economic prosperity now and in the future.

Consequently, there is a responsibility on schools to actively promote STEM subjects and careers. Research conducted by Nestle UK &Ireland (2014) indicated that, "nearly four out of five 14 to 16-year-olds would consider a career in a science, technology, engineering and maths (STEM) related industry, but more than half of those surveyed admitted that they knew very little about the type of jobs on offer." When Nestle UK &Ireland (2014) surveyed math and science teachers; 52 percent of them stated they didn't know what STEM related businesses were looking for in new recruits. In addition to this, Archer *et al*. (2005, cited in Watts, 2014) stated, "the curriculum lacks explicit teaching about STEM-related career opportunities, and students of all ages lack awareness of the breadth of job opportunities that would be available to them with science qualifications." Schools and teachers would need to have in-depth knowledge on STEM careers if we are to increase the number of pupils pursuing and being successful in these careers.

Key point emerging.

Gaining this understanding of how an economy works, enables one to better appreciate the recent demands for increased skilled workers in STEM careers. The literature reveals worrying statistics that pupils are not gaining an appreciation of STEM career opportunities in school and that teachers lack knowledge of the skills and attributes sought by STEM employers.

What does this mean for schools?

In light of this, perhaps there is a requirement for school initiatives to focus on the skills and attributes required for STEM industries and for teachers to increase their competence and knowledge in this area.

The importance of women in STEM industries

Every economy should promote equal opportunities for women. Consequently, is the recent ambition to increase the number of females in STEM industries an equality issue or is it due to women possessing a particular set of skills and qualities which would improve creativity and productivity in STEM industries? It is essential that all potential entrepreneurs are encouraged to create their own business. If only men were allowed to start their own businesses, we would never know the potential business ideas women could bring. Lo (2015, cited in Northern Ireland Assembly, 2015) argues, "the under-representation of women in STEM jobs is not just a gender equality issue. There are wider economic consequences for our economy and international competitiveness…if we fail to inspire our young females, we are not maximizing the potential pool of talent from both sexes."

Perhaps the recent aspiration to encourage more females into STEM based careers has a dual purpose; to ensure fairness in equality and to ensure the economy is not missing out on the potential ideas, skills and qualities of women. A spokesman for the Department of Education (2015, cited in Richardson, 2015) stated, "getting more girls into careers in science, technology and engineering is a key priority for this government, and is why we are encouraging more women to study STEM subjects - helping bridge a gap in our future economy and getting them on the path to some of the highest paid careers."

Key point emerging.

From a governmental point of view, the reason for the increased need for females in STEM based industries is both to ensure equal opportunities for all and to gain the best success for the economy. The economy is failing to reach its potential because not enough young people, in particular young females, are being encouraged to study STEM subjects and careers.

What does this mean for schools?

It is apparent from the literature that schools need to focus more on encouraging female pupils in particular to study STEM subjects and careers. Perhaps schools could invest in some strategies that solely target the female population.

The brain

The brain of a male is larger than that of a female. Despite this, both gender types have exactly the same amount of brain cells. Therefore, it can be confirmed that no gender is more intelligent than the other. Researchers have discovered strong evidence suggesting males and females use two different areas of the brain to solve problems. Boaler (2010, p. 124) recalls the time when participants were asked to mentally rotate three-dimensional shapes. She ascertained they were equally good at it but had used completely different brain circuits. This research confirms the idea that the brain of a female and male are equally intelligent but suggests they may be suited to different tasks. Thus, both genders would be potentially beneficial in STEM industries.

Watts (2014, p.43) identified studies carried out on the difference in innate mathematical ability in males and females. These studies showed that boys tend to score better in visual-spatial skills testing than girls, while girls tend to outperform boys in verbal ability tests. Both of these skills are important for good performance in STEM subjects and careers. Generally, it has been found that women have an inquisitive mind and do not just accept something as truth (Boaler, 2010, p. 124). This quality, teamed

up with the rational brain of the male, could be the ingredients required for successful STEM industries. Furthermore, amongst a mixed group of students who all claimed to find physics interesting, significantly fewer girls cited practical work as the main reason for the interest, compared to boys (Williams *et al*., 2003).

Key point emerging.

Subsequently, men and women do differ in their talents and areas of interest within STEM subjects and so both are required for STEM industries to enhance the diversity of skills and attributes present in the work force.

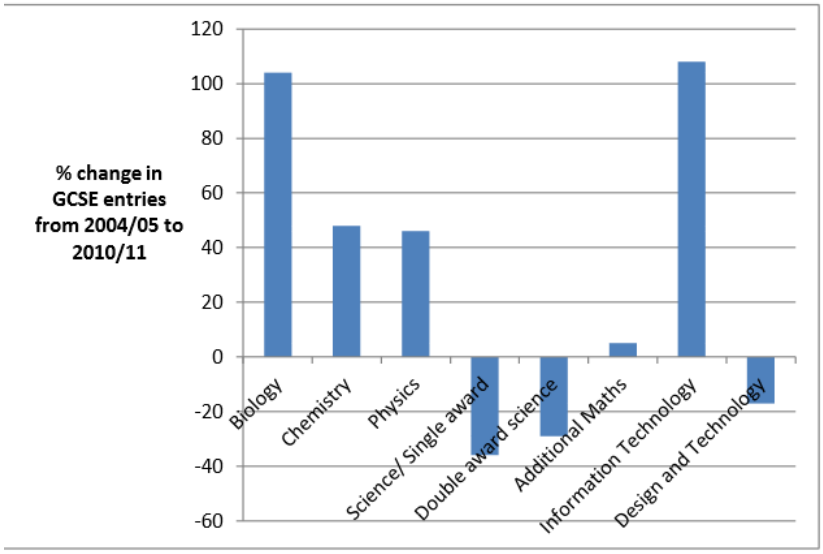
What does this mean for schools?

Schools should be aware of the importance of increasing pupil confidence when teaching the STEM subjects and be sure to show equality when teaching STEM subjects.

The current situation

Perry (2012) published data illustrating an, "upward trend in the number of STEM subjects being studied at GCSE level."

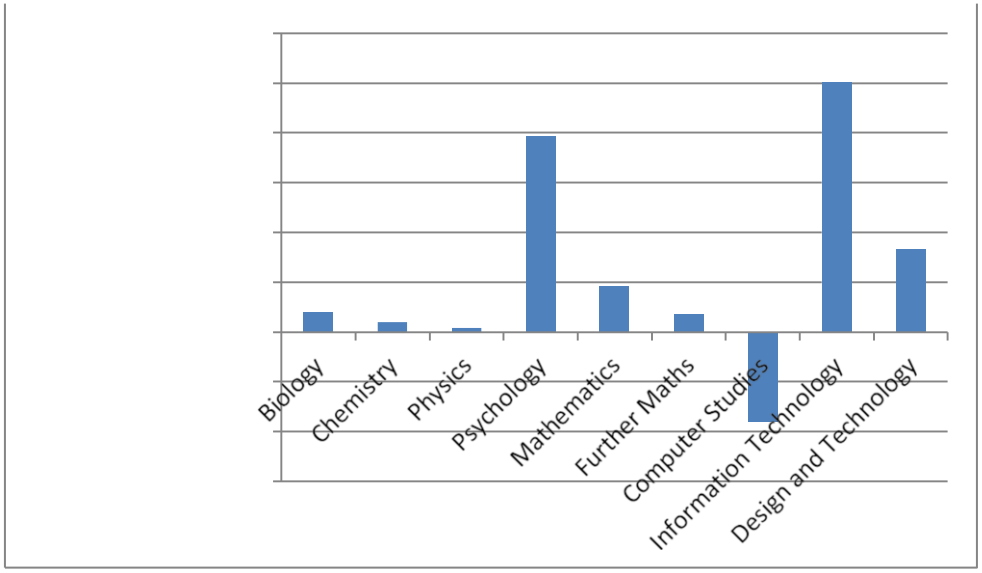
Figure 1: Percentage change in GCSE entries in STEM subjects in NI post-primary schools 2004/05 – 2010/11



The data show there is a decline in the number of pupils studying both single award and double award science. However, more pupils are choosing to study the STEM subjects separately.

The research clearly shows an increase in the number of pupils studying STEM subjects at GCSE level. However, many post-primary schools make STEM subjects compulsory at GCSE level. Thus, the research

does not suggest interest and enthusiasm for STEM subjects is increasing but instead indicates schools are doing more to ensure pupils study STEM subjects to at least fifth year.
Perry (2012) continues to demonstrate that, "at A-Level the STEM subjects are not experiencing the same success in percentage increase."



Subjects such as biology, chemistry and physics are experiencing an increase but it is minimal.

Figure 2. Percentage change in A level entries in STEM subjects in NI post-primary schools 2001/02 – 2010/11.

These data indicate fewer pupils are continuing to study STEM subjects to KS4 level, inevitably decreasing the number of pupils entering STEM degrees. This coincides with previous literature discussed which suggests there is an insufficient number of skilled workers in STEM based industries.

Thus far, the literature discussed has identified a need for more pupils in all of the STEM subjects and careers. The Council for the Curriculum, Examinations and Assessment (2015) release statistics on the number of pupils entering exams in each subject with a consideration of gender and type of school. When these statistics are analysed it is evident that not all STEM subjects are lacking in numbers. In reality, A-Level biology and mathematics are highly populated. Furthermore, not all of the subjects exhibit a gender imbalance as the previous literature suggests.

Table 1.

Subject Name and Code		Candidates Examined	Cumulative Percentage of Candidates in Each Grade					
			*	A	B	C	D	E
[A2211]	GCE MATHEMATICS							
	Grammar	Males	1213	18.5	52.0	79.7	92.0	97.0	98.8
		Females	949	18.1	54.3	81.8	93.7	98.0	99.7
		Total	2162	18.3	53.0	80.6	92.7	97.5	99.2
	Non-Grammar	Males	164	7.9	28.0	54.3	78.0	89.6	93.3
		Females	147	4.8	24.5	57.8	79.6	91.2	96.6
		Total	311	6.4	26.4	55.9	78.8	90.4	94.9
	Further Education	Males	51	0.0	25.5	52.9	70.6	80.4	88.2
		Females	33	3.0	15.2	33.3	48.5	66.7	81.8
		Total	84	1.2	21.4	45.2	61.9	75.0	85.7
	Other	Males	1	0.0	0.0	0.0	100.0	100.0	100.0
		Females	3	0.0	0.0	100.0	100.0	100.0	100.0
		Total	4	0.0	0.0	75.0	100.0	100.0	100.0
	Overall	Males	1429	16.6	48.3	75.8	89.6	95.6	97.8
		Females	1132	15.9	49.1	77.3	90.5	96.2	98.8
		Total	2561	16.3	48.7	76.5	90.0	95.9	98.2

Table 1: From the yellow box we can see there is a smaller number of females than males sitting mathematics in grammar schools. From the blue box, we can see that females, however marginal, tend to outperform males in mathematics at grammar schools. In the green box we can see that in further education there is again a smaller number of females studying mathematics but this time with males outperforming the females as seen in the red box. The aggregated data show negligible gender difference in attainment in mathematics. Furthermore, mathematics is a highly populated subject at both school level and further education.

Table 2.

Subject Name and Code	Candidates Examined		Cumulative Percentage of Candidates in Each Grade					
			*	A	B	C	D	E
GCE BIOLOGY								
Grammar	Males	796	10.1	36.1	68.8	88.6	96.4	99.6
	Females	1362	13.5	39.9	70.9	89.4	97.0	99.5
	Total	2158	12.2	38.5	70.1	89.1	96.8	99.6
Non-Grammar	Males	110	4.5	16.4	39.1	64.5	79.1	95.5
	Females	263	2.3	16.3	40.7	68.1	85.6	93.9
	Total	373	2.9	16.4	40.2	67.0	83.6	94.4
Further Education	Males	55	0.0	14.5	40.0	60.0	76.2	89.1
	Females	92	2.2	9.8	29.3	54.3	73.9	85.9
	Total	147	1.4	11.6	33.3	56.5	75.5	87.1
Other	Males	3	0.0	33.3	33.3	66.7	100.0	100.0
	Females	14	0.0	14.3	28.6	57.1	85.7	85.7
	Total	17	0.0	17.6	29.4	58.8	88.2	88.2
Overall	Males	964	8.8	32.6	63.7	84.1	93.4	98.5
	Females	1731	11.1	34.5	63.7	84.0	93.9	97.8
	Total	2695	10.3	33.9	63.7	84.0	93.7	98.1

Table 2: From the yellow and red boxes we can see that in grammar and non-grammar schools there are many more females than males studying biology. The females are only outperforming the males by a marginal amount in grammar schools and both genders are obtaining similar achievement in non-grammar schools as seen in the blue and green boxes to the right of them. From the purple box we can see there is a larger number of females studying biology at further education with the males outperforming the females in this case as seen in the grey box. Aggregated data show that surprisingly there is a gender imbalance in the opposite direction for A-Level biology in schools and further education. The difference in levels of attainment are marginal in schools, until further education when males tend to outperform females. Furthermore, biology is a highly populated subject at school level but numbers drop at further education.

Table 3.

Subject Name and Code	Candidates Examined		Cumulative Percentage of Candidates in Each Grade					
			*	A	B	C	D	E
GCE PHYSICS								
Grammar	Males	859	10.1	36.2	65.0	83.6	94.2	98.4
	Females	309	8.1	37.9	64.4	85.1	94.5	98.4
	Total	1168	9.6	36.6	64.8	84.2	94.3	98.4
Non-Grammar	Males	61	0.0	15.1	39.5	63.9	85.2	95.1
	Females	36	0.0	30.6	58.3	77.8	83.3	94.4
	Total	97	0.0	19.6	46.2	68.1	84.5	94.8
Further Education	Males	37	0.0	16.2	32.4	73.0	83.8	91.9
	Females	9	0.0	0.0	22.2	22.2	77.8	88.9
	Total	46	0.0	13.0	30.4	63.0	82.6	91.3
Other	Males	2	0.0	0.0	50.0	100.0	100.0	100.0
	Females	0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	2	0.0	0.0	50.0	100.0	100.0	100.0
Overall	Males	969	9.1	33.9	61.4	83.2	93.7	97.9
	Females	354	7.1	36.2	62.7	82.8	92.9	97.7
	Total	1513	8.6	34.6	61.9	83.3	93.5	97.9

Table 3: Looking at the yellow, red and purple boxes there is a significantly lower number of females studying physics in both types of schools and also in further education. Looking at the blue and green boxes females are outperforming males at school level. The grey box shows that in further education males are outperforming the females by a significant amount. There is a substantial difference in numbers of males and females studying physics at both school level and further education, females tend to outperform males at school level but when they reach further education the males begin to outperform females. Furthermore,

An overview of the statistics seems to suggest that more females study STEM subjects at A-Level and they tend to outperform males at school level. A report in BBC news agrees with this as, "the number of girls taking so-called STEM subjects - science, technology, engineering and mathematics - at A-level has seen a notable increase. There was a significant rise of 8.6% in the number of students taking A-levels in mathematics, with 10.6% more entries from girls" (BBC News, 2015). However, when it comes to further education the number of females decreases and so too does the level of attainment in females, with males outperforming them at this level of education. The STEM business group (2013) coincides with this, "A-Level Physics (31% females), Mathematics (43% females), Further Maths (25% females), Design and Technology (25% female) and Computer/IT related subjects (41% female) are subjects where the gender bias is most marked."

Key point emerging.

The CCEA data indicate that it is not every STEM subject where there is a lack of pupils and where the gender imbalance is occurring. Therefore, current literature which comments on the decline in uptake of all the STEM subjects is questionable. It is imperative to note that whilst there may be a significant number of females studying subjects such as mathematics and biology at A-Level, statistics show that fewer females are continuing to study these subjects to further education. Thus, literature stating the

lack of females in all STEM industries and careers may still be plausible.

What does this mean for schools?

In light of this, perhaps the school initiatives are successful in encouraging pupils to study STEM subjects at A-Level but are failing to motivate pupils in STEM degrees and careers. There may be a requirement of schools to create new approaches to increase interest in STEM careers rather than the need to encourage more into STEM subjects at A-Level which is not where the problem lies. Furthermore, there may also be a requirement for the initiatives to target specific subjects such as physics, engineering and technology since it is not every STEM subject and career that is experiencing a decline in numbers.

Possible reasons for the STEM gender imbalance

Single sex verses co-educational STEM education

Research has shown that girls feel more comfortable to take risks and are not deterred by potential disdain from their male peers when learning math and science in single sex schools. Girls who attend all-girls schools are "six times more likely to earn degrees in the "hard sciences" and "math" compared to girls who attend co-ed schools" (Streitmatter (1997, cited in Spikes, 2008, p.207)). Additionally, Accenture (2015) revealed that "60% of girls aged 12 in the UK and Ireland felt that mathematics and science were 'too difficult' to learn and better suited to boys because of their brains, hobbies and personalities."

These studies allude to the idea that single sex education is more credible. The reality is, however, that maths and science careers are predominantly male engaged. Therefore, perhaps it would be more reasonable for girls to learn alongside their male counterparts from a young age which would prepare them for the future workplace.

Key point emerging.

Undeniably, statistics may show females are more likely to pursue STEM careers when attending a single-sex school. If this is the case, there is a need to address how co-educational schools can learn from single sex schools and ensure that girls feel confident when learning alongside their male peers.

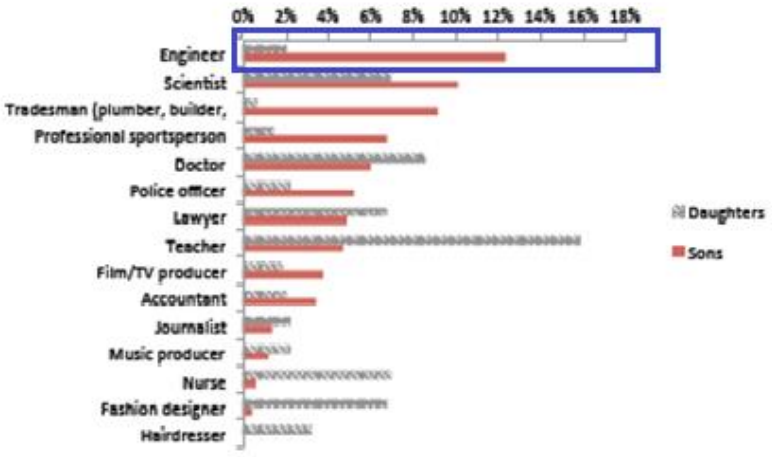
What does this mean for schools?

This again highlights the possibility that schools should invest in more initiatives which target females specifically. Or, perhaps schools could teach STEM subjects in gender groups initially to allow pupils to build confidence and then integrate the genders at a later stage.

Parental influence on children in science

Accenture (2015) found that young girls cited parents as their biggest influencers. This highlights the importance of parents having the skills and knowledge to ensure their child grows up in an environment with a high 'science capital'. A study by Campaign for Science and Engineering (2014) revealed how the stereotyping of careers by gender is evident in parents' aspirations for their children.

Figure 8 –
Parents' responses[48] to the question "What type of job would you most like your child to pursue when they finish their education?" show gender bias[49]



This research shows gender bias through the responses from parents when they were asked, "What type of job would you most like your child to pursue when they finish their education?" We can particularly see from the highlighted blue box in the table that 2% of parents wanted their daughter to become an engineer in comparison to 12% of parents who wanted their son to become an engineer.

Lyons (2006) found evidence to suggest that parents tend to think their daughters are less interested in science than their sons. Watts (2014, p.45) commented on the common misconception of families that physics is very difficult. He said, this impression is further exaggerated in families with a low 'science capital' since they have a lack of familial connection with science and scientists. These families also tend to have a lack of knowledge about the wide range of career opportunities that are available to a person with STEM qualifications.

Key point emerging.

If parents have as large an influence on their children's career choice as this research suggests they do, then something needs to be done to change the attitudes and perceptions of parents in relation to female careers.

What does this mean for schools?

Schools cannot work in isolation. Parents need to be addressed when considering approaches and initiatives employed by schools to increase uptake of STEM subjects and careers.

Lack of female role models

Will.i.am, a member of a popular 21st Century band, "The Black Eyed Peas" is an advocate for STEM education. "Will.i.am believes that typically the science and engineering subjects in schools are not perceived as culturally "cool" and so his aim as an advocate is to challenge the perceptions of STEM subjects" (Girls Tech Movement, 2013). Undoubtedly, the work of Will.i.am has had an impact in the promotion of STEM subjects. There is no female equivalent, hence there is a niche for a famous female

to be an advocate for STEM. A report by WISE (2013) outlined encounters with professionals as one of the most effective ways of attracting girls into STEM-related careers, "60% of females said they were put off by the lack of female role models in science."

Contrastingly so, the importance of female role models has been challenged by some researchers. Buck *et al.* (2002) tested their importance when he invited a number of female scientists into a classroom to try and overturn the 'scientist equals man' stereotype. He deduced that the pupils did not recognise them as scientists and instead assumed they must be teachers. Thus, he concluded that the presence of female role models did not change the perceptions and thus, would not help to increase the number of females studying STEM subjects.

Key point emerging.

There is a substantial under-representation of female scientists in the media and so a female role model would be advantageous to the promotion of STEM subjects within the female population. Controversy over the effect of female role models shows that they may not help to remove the negative stereotype, however, they could still be advantageous in increasing knowledge of STEM opportunities and female confidence in studying STEM careers.

What does this mean for schools?

Schools should do more in pointing out successful females in STEM careers. Schools should make their pupils aware of females either within the media or within the local community who are pursuing and succeeding in STEM careers.

Teaching and learning of STEM subjects

The teaching and learning of STEM subjects and student-teacher relationships are major factors contributing to STEM subject choices and career decisions. Guzzetti and Williams (1996, cited in Watt, 2014, p.53) observed that in many physics text books, people featuring in the pictures tend to be men. Within the curriculum, it is fundamental that the resources used do not exhibit any stereotypes that would deter either gender.

In addition to this, researchers say that talking to female pupils about the under-representation of females in STEM careers throughout lessons has an impact on them, "when girls are engaged in discussions surrounding under-representation of females in STEM industries, this has been shown to have a positive impact on them" Hazari et al. (2005, cited in Watts, 2014, p.52).

Key point emerging.

Teaching and learning of STEM subjects are at the heart of pupil motivation and interest in STEM careers.

What does this mean for schools?

Schools need to ensure their science curriculum targets both genders and does not exhibit any gender stereotypes or negative messages. Perhaps schools could do more in making female pupils more aware of the under-representation of females in STEM careers as this has been shown to increase their motivation to pursue these careers.

Conclusion

The literature raises the wide range of issues that are feeding the STEM gender imbalance. I aspire to investigate how the initiatives in the STEM agenda of a post-primary school are targeting these issues and how, if at all, they are succeeding in increasing the 'science capital' of pupils and ultimately increasing interest and motivation in STEM subjects and careers.

Consequently, my research questions for the study are as follows:

1. What initiatives are being used in one post-primary school to raise the profile of 'science capital' within pupils and the parent body/community?
2. What effect are these initiatives having on interest and motivation in STEM subjects and careers?
3. How can I create a professional development resource to inform other single sex schools and indeed co-educational schools about these initiatives to ensure that females are not left out of STEM education?

Methodology

A clear focused title and research questions are essential in enabling one to comprehend precisely what they are investigating in a research project. It is these that will influence the selection of the most appropriate research methods which will determine the outcomes and overall success of the project. "Having formulated one or more research questions or set up a hypothesis, the social researcher is faced with the task of designing research that will enable her to gather data to address the research questions or hypothesis" (Matthews and Ross, 2010, p. 181).

Type of research and rationale

Sechrest and Sidani (1995, cited in Smith, 2015) know that "Quantitative researchers take an objective, detached stance towards research participants and their setting, whereas qualitative researchers become personally involved with research participants." Quantitative data are more concerned with collecting numeric data with an aim of presenting the data in a graphical or pictorial form. Qualitative data are the collection of more personal data and allow for in-depth inquiry and an understanding of the participants involved in the study. Quantitative data are more suited to a study concerned with providing correct and accurate answers whereas qualitative data are more suited to a study that involves questions of which the answers are not immediately obvious. Research methods whereby I can ask open ended questions and discuss issues with appropriate participants will be more beneficial to the

overall aim and purpose of my study. It is for this reason that I have chosen to use qualitative research methods.

Madrigal and McClain (2012) explain:

> Qualitative research studies can provide you with details about human behavior, emotion, and personality characteristics that quantitative studies cannot match. Qualitative data includes information about user behaviors, needs, desires, routines, use cases, and a variety of other information that is essential in designing a product that will actually fit into a user's life.

Accordingly, my ambition is to make a professional development resource for use in future practice which further supports my decision to use qualitative research methods.

Methods of research

Interview with STEM teacher

Interviews are a frequent and very effective method of generating data in qualitative research. Seidman (2013, p. 24) states, "At the root of in-depth interviewing is an interest in understanding the lived experience of other people and the meaning they make of that experience." Conducting an interview with a STEM teacher in the school will enable me to understand the opinions and attitudes of the teacher who has been actively involved in approaches to increase 'science capital' and promote STEM. I hope to understand what he thinks has caused the success of their strategies, what issues he feels still need to be addressed and how he thinks other schools can learn from these strategies. I am aware that the structured layout of interviews can constrict the data collection and may not allow for further opinions and ideas from the interviewee. Whilst my interview has a set of structured questions, I do intend to let the layout of the interview be subject to change so as I can learn from the teacher's experience and understand his views and opinions.

To ensure the authenticity and viability of my data I am required to access a sizeable percentage of pupils and parents in the participating school. Interviews would be effective for this, however, they are time consuming. Thus, in order to assess as many participants as possible and use a method of research that is in sync with the time constraints of this project, I will send out questionnaires to parents and carry out some focus group sessions with pupils. This will allow for greater number of participants to be targeted in a small space of time, generating a larger range of opinions for validity and reliability of my research.

Questionnaire for parents

Structured questionnaires are commonly used to collect quantitative data, and unstructured questionnaires are commonly used to collect qualitative data.
The University of Sheffield (2014) express that:

> Unstructured questionnaires, whilst still having a structured sequence and focus predetermined by the evaluator, are based on open questions allowing respondents the freedom to answer in their own words and therefore to provide greater qualification in their response.

Since I have chosen to collect qualitative data I will use unstructured questionnaires for the parents. This will allow for more intimate questions which suits the aim and purpose of my study which is to understand attitudes and opinions of the parents. In questionnaires, questions may be interpreted differently by different participants. In an attempt to decrease the possibility of this occurring I have been meticulous in composing questions that are concise and unambiguous. Moreover, my questionnaire will be piloted to ensure the clarity, sensitivity and appropriateness of questions asked.

Focus groups with pupils

"Focus groups offer a more in-depth understanding of the target's perspectives or opinions and allows researchers to capture subjective comments and evaluate them" (Edmunds, 1999, p.2). It is with this in mind that I have chosen to conduct a number of small focus groups with the pupils of the school. These pupils will have first-hand experience of the strategies and approaches used by the school to increase 'science capital' and STEM interest. Thus, using a focus group will enable me to discuss their opinions on the strategies used and also inquire the extent of their individual 'science capital' as a result of these strategies. I realise focus groups will only enable me to represent a small sample of pupils, however, I am not interested in obtaining quantifiable results. Instead, I am more interested in the detailed perspectives and opinions of the pupils who are experiencing these initiatives on the ground. I hope also that these pupils will suggest some ideas for the creation of my resource.

The methods of research described have been chosen due to their ability to understand the attitudes, opinions and experiences of the teacher, pupils and parents. My research is not interested in providing statistics because statistics require numbers which I have not got. Instead my research will inquire about and appreciate the values and opinions of participants involved so as to create a resource which will improve practice in the future.

Ethical considerations

A consideration of the BERA ethical guidelines has enabled me to appreciate the importance of ethics when carrying out research. The BERA Association (2011) considers that, "educational researchers should operate within an ethic of respect for any persons involved in the research they are undertaking. Individuals should be treated fairly, sensitively and with dignity…" Before carrying out any research in the chosen school, I will obtain written and verbal consent from the principal. The association (BERA Association, 2011) outlines that any person taking part in a study for the purpose of providing information must sign a voluntary consent. Prior to the interview, I will send a letter of consent along with a list of the questions that will be asked on the day of the interview to the STEM teacher. A letter of consent and a draft of both questionnaires and focus group questions will be given to the parents and pupils involved. All of the participants will sign a consent form stating they understand and agree to their participation in my research before any information obtained from them is used. Furthermore, since the responses may contain sensitive information all hard copies of responses will be kept in private storage and will be terminated at the end of the research study. In order to protect the confidentiality of participants their names will not be disclosed throughout the research paper. Further to this, I completed an ethics review form.

Thomas (2013, p.13) states,

> All research contains the same basic ingredients – having a question, discovering what others have done, refining your question in light of that discovery and then going out to answer the question yourself…There's an immense pleasure in finding something new and presenting it in a form that people can understand.

I am confident that the research methods I have chosen are the most appropriate for the nature of my study. The research will provide a greater insight into the importance of 'science capital' in increasing motivation for STEM careers. It is hoped that the research discovered will enable me to create a professional development resource that can fit into future practice. This resource will aim to reduce the gender imbalance and bring us closer to the overarching aim of its obliteration.

Presentation and analysis of data

The school I conducted my research in was recommended to me by W5[1] due to its recent success in the promotion of the STEM subjects and careers. The school, which was named the first of twelve Specialist Colleges in N Ireland, has a driven atmosphere in relation to careers and strives on the success of their pupils. This comprehensive college is set in one of the most socially deprived areas in N Ireland, and caters for all abilities.

Current school statistics prove the success of their recent STEM agenda in so much that 88% of female pupils at A-level are currently studying at least one of the STEM subject disciplines. In particular, there are 70 female pupils studying A-Level physics, a subject which statistically suffers great male domination as suggested in the CCEA data (2015) within my literature review. The STEM teacher commented that their success has been a result of their high expectations that any one of their pupils will be successful in a range of male dominated careers and their aim to ensure that STEM has a visible place in the curriculum.

Strategies in place to embrace 'science capital'

School and classroom

The school has a particular interest in strengthening their links with local primary schools. They run a fantastic yearly programme called, "Step up to STEM" which involves participation from 20 primary schools and over 1000 pupils. This programme is successful in addressing the important issue of early intervention when promoting 'science capital' as suggested in the report from the Department of Education & Professional Studies (2013) in my introduction. The programme also works to smooth the school transition period by removing the 'fear' stigma attached to STEM subjects. Its aim is to empower all pupils to have the confidence to study STEM subjects especially females who often think science is too difficult for them and more suited to males; an issue identified in my literature review by Accenture (2015).

Teaching and learning

The school has two vice principals one of whom is dedicated to teaching and learning and one who is dedicated to pastoral care. The VP who is dedicated to teaching and learning is also the chair of the STEM committee. The committee is made up of 6 STEM teachers in the school. They meet fortnightly to discuss potential strategies and the success or lack thereof current strategies. One of their strategies

[1] **W5** is an Interactive Discovery Centre in **Belfast**, Northern Ireland, and is Ireland's award-winning science and discovery centre at the Odyssey in **Belfast**.

which particularly impressed me was the use of display boards throughout the STEM subject disciplines. Each of the STEM subject departments have a themed corridor with display boards which show how the subject is connected to the other STEM subjects. This reinforces the important idea, which I had not considered in my literature, that the STEM subjects are linked and should not be seen as a single identity. I had the opportunity to walk down the math corridor and have taken pictures of these effective displays for my resource so as other schools can adopt this strategy. The technology teacher alluded to the success of these display boards in opening up STEM conversations among the pupils.

With the help of GTCNI, the STEM committee also developed an effective strategy called, 'The Learning Threes.' This strategy is used across all subjects; the STEM teachers are strategically placed in their threes together. Three STEM teachers work together on a lesson plan in an attempt to incorporate a range of cross curricular aspects to that lesson. One of the teachers in the group of three will then deliver the lesson to a class whilst the other two teachers observe how the pupils react to the lesson. Time is made to allow this strategy to occur at least three times a year so as three lessons have been improved and all three teachers have had the opportunity to deliver the lesson and observe. This strategy again addresses connected learning across STEM subject disciplines and subject departments which I had not considered in my literature review.

Working with STEM industries and experts

Within my literature review, Nestle UK &Ireland (2014) released a worrying statement that school teachers and pupils are not aware of the specific skills and attributes sought by STEM industries. The school addresses this issue very successfully as they have relationships with many STEM industries who give them instrumental support and information. The teacher stated there was a lot both pupils and teachers could learn from STEM industries and that every school should invest in opening up links and positive relationships with STEM industries. The school engage in a 'learning by doing' policy whereby every pupil must take part in a week of work experience in year 10 and again in year 12; the two years before crucial subject choices are made for GCSE and A-Level respectively. The teacher conveyed the success this particular strategy has received. He suggested it a great idea that teachers take opportunities to visit STEM industries with their pupils where possible and admitted, "I didn't do a STEM degree or apprenticeship, I did a teaching degree which didn't teach me about the skills, attributes and type of work involved in STEM industries" (personal communication, November 2015).

The school also engages in a process whereby they invite past pupils back to the school to talk about their occupation and career pathway. The teacher said that hearing from a familiar face who had come from the same position and gone on to be successful in a STEM career was invaluable to the promotion of STEM careers. This strategy is highly useful in that it addresses many of the issues in literature such as the need for more female role models (WISE, 2013) and also makes the pupils aware of the many STEM opportunities available to them. I also think this link with past pupils excellently targets the critical issue identified from the CCEA (2015) statistics that perhaps many strategies only encourage pupils to study STEM subjects at A-Level but not enough of them encourage pupils who are already studying STEM subjects at A-Level to pursue them as a career.

Parents and community

In the literature, Accenture (2015) claimed that parents have the greatest influence on females when deciding their career choices. The school exhibits an 'open door policy' with parents. They acquire and

develop relationships with parents through the use of coffee mornings and prayer services. STEM Immersion days occur throughout the year whereby year eight pupils showcase their STEM projects to their parents and relations in the wider community. The teacher stated that whilst this strategy was a great idea, the problem arose that getting parents in specifically for STEM events was extremely difficult. On evaluation of these immersion days the school has implemented the idea of disseminating STEM information from pupils to parents. It is hoped that by the pupils engaging in numerous STEM activities in school, they will go home and talk about it which will encourage the parents to understand that something important is happening. In my opinion, this strategy lacks substance as there is no guarantee that pupils will go home and talk to their parents about the STEM activities and so more work is required here.

Outside agencies

The school has links with many outside agencies such as BELB, STEMNET and the W5 STEM Ambassador programme. These outside agencies engage pupils in STEM talks and activities, invite the school on day trips and on some occasions have provided the school with funding for internal projects. Through these invaluable outside agencies pupils are encouraged to enter competitions such as "Miss STEM" and "Young Scientist of the Year" and have also been given the opportunity to visit Queens University Belfast. This addresses the predominant issue of 'science capital' throughout my entire project. Pupils who are not engaging in scientific discussions at home are not able to appreciate that science has a life outside the classroom. In my opinion, outside agencies are crucial to the promotion of science as a key element of life and not just a classroom subject.

The STEM teacher voiced his gratitude for the outside agencies. He stated that much of the school's success had come from the work of outside agencies. He said they were important in allowing pupils to think about STEM outside of the classroom since a lot of the pupils came from families who had a low 'science capital' and felt science was too difficult. This combats the issue raised in my literature review by Watts (2014, p.45) who commented on the common misconception of families that physics is very difficult.

Limitations

These strategies have received much success in raising the profile of 'science capital' within the pupils and parent body/community and have consequently increased interest and motivation in STEM subjects and careers. Whilst the research undergone in this post-primary school is viable it does have its limitations. The research was carried out under small scale numbers and so, cannot be said to be statistically conclusive. The strategies discussed have received success in this post-primary school, however, there is no evidence to suggest that they would be successful in all schools. Accordingly, there is an acknowledgment by the STEM teacher of the school that the strategies implemented were tailored to suit the comprehensive, mixed ability nature of their school. A number of the initiatives used required much money and resources which were in some cases provided to the school by outside agencies. Other schools may not have the same proximity to outside agencies and thus, may not have such an extensive budget. However, due to the extent of the success and the wide range of strategies used it can be said that all schools could learn from some aspects of their initiatives and should strive for similar success.

Discussion and conclusions

Research Questions
What initiatives are being used in one post-primary school to raise the profile of 'science capital' within pupils and the parent body/community? What effect are these initiatives having on interest and motivation in STEM subjects and careers? How can I create a professional development resource to inform other single sex schools and indeed co-educational schools about these initiatives to ensure that females are not left out of STEM education?

Did I achieve my research objectives and answer my research questions?
Throughout my study, I have successfully investigated the strategies implemented in a post-primary school which attempt to raise the profile of 'science capital.' In investigating these strategies, I have assessed the impact of them in increasing interest and motivation of pupils in STEM subjects and careers. Many of the strategies have been met with outstanding success and I believe this school is a model school for other post-primary schools. I have developed some key recommendations for a small number of the strategies which would improve their success in order to fully answer my final research question. The STEM teacher of the school admitted that he is proud of the immense success of their strategies, however, more could be done to improve them as the school is still not completely free of the STEM gender imbalance. Further to this, the strategies have been used over a number of years. Their success was gradual, thus, as with any school based initiatives and strategies a longitudinal view must be taken.

The idea of encouraging 'science capital' is prevalent throughout my project. I reiterate the opinion of the Department of Education & Professional Studies (2013) that the promotion of 'science capital' is an imperative aspect of increasing STEM uptake and motivation. However, I do challenge the validity of the statement from them which alludes to the idea that females coming from a family which does not exhibit a 'science capital' do not express interest in STEM subjects at age 10 and are unlikely to develop STEM aspirations by the age of 14. Whilst I understand the importance of early intervention in bettering the chances of success, I believe there is an alcove in post-primary education to re-engage females into science if they focus on embracing the 'science capital' of their parents and pupils. Hazari et al. (2010, cited in Watts, 2014) reported that many of the females who are now physicists first became interested in the subject in their high school years.

Conclusions from research
From Nestle UK & Ireland (2014) and my research, I identified the problem that teachers, pupils and parents have a lack of awareness of STEM career opportunities and the skills required to be successful in these careers. I strongly believe schools cannot work in isolation; opening links with STEM industries is a crucial aspect of increasing STEM knowledge and awareness. Teachers themselves will most likely have no experience of working in STEM industries, thus, STEM specialists are essential in providing experienced information on career pathways and skills required. I am of the opinion that links with STEM industries would be invaluable to schools and I also suggest that teachers should be encouraged to learn from STEM specialists to improve their teaching of STEM careers. WISE (2013) and the focus group session recognised a lack of female role models in STEM education. Opening links with STEM industries would provide contacts for the pupils and teachers to females in STEM careers. I think the

invitation of past pupils into the school to speak to pupils is an extremely effective strategy in addressing this issue and should be used in all schools.

The importance of connected learning within the STEM disciplines became apparent to me from my research. Collaborative work within the STEM subject departments in the school has contributed widely to their success. It is through the excellent approaches of the school such as the themed corridor and the 'Learning Threes' that pupils can begin to enjoy learning about STEM and start to think about STEM subjects as connected disciplines instead of separate identities. Furthermore, enabling teachers to identify failing strategies and celebrate the success of other strategies in the STEM committee is highly effective and should be used in any educational strategy implemented in schools.

A third conclusion falls on the difficulties faced by post-primary schools to increase the 'science capital' of parents and the community. When asked about this, the teacher stated this was perhaps the most difficult challenge in the promotion of STEM. Feedback from the parents also suggested they would like to know more about STEM and the career opportunities available within it. The school has attempted many strategies in relation to this which have had great intentions, however, I believe more work is required on them. In order to improve this strategy, I suggest that schools utilise the increasing dependence on technology and use of smart phones in today's society. I suggest that schools create a point of contact between parents and teachers which would not require them to physically meet to learn about STEM (I have addressed this issue in my resource in the creation of a Fronter room). Accenture (2015) alluded to the idea that parents are the most influential people in a child's career pathway and outlined alarming results that most parents do not envisage their daughter going into a STEM career. If we are to effectively remove the STEM gender imbalance more needs to be done in this area to remove the negative gender perceptions parents have with STEM careers.

Recommendations for future research

Having completed my research study, I believe there is scope to develop more research into how the strategies implemented in this school could be implemented in a co-educational school. The idea that females are more likely to pursue a career in STEM when attending a single sex school is one that sparks much controversy. Research could be done to assess the extent of STEM subject uptake in single sex schools compared to co-educational schools. In my research in the single sex school, the focus group discovered that all pupils had confidence in themselves to pursue a STEM career and did not think boys were over and above them when it came to success in STEM subjects. Moreover, research in literature stated girls were put off STEM subjects when learning alongside their fellow male peers (Streitmatter (1997, cited in Spikes, 2008, p.207)). During the teacher interview it was suggested that perhaps co-educational schools could introduce positive discrimination and separate females and males when learning about STEM. I believe a comparative study into the benefits of single sex education and mixed education would be beneficial to the eradication of the STEM gender imbalance.

Recommendations for future practice

The discussions and conclusions outlined here are not trying to suggest that the strategies implemented in this all-girls school need improvement. They are merely suggestions and are not claiming to be successful in any way. This project has been a worthwhile study which has resulted in a creative and innovative professional development resource using Fronter. The resource promotes the successful strategies found in this research and also identifies issues which still needed to be addressed. I am

confident this resource can be of use to post-primary schools in the future for the promotion of STEM and have uploaded my Fronter resource onto 'Equella' (an online resource bank which all schools have access to).

The capstone project has not only taught me invaluable knowledge on conducting a research project but has also increased my competence of creating a Fronter room which will be useful when working in a post-primary school in the future. The research project has also improved my awareness and appreciation of issues surrounding STEM and the importance of the STEM disciplines for the local and global economy. This will be of particular use to me in the future as I embark on my post-primary teaching career in math and science.

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