

**Impact of Bridge 21 model on female students' confidence in STEM and Computing:  
Aligning the model to bridge the gender gap in STEM through a 21<sup>st</sup> century skills based  
intervention**

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*in partial fulfilment of the requirements for the degree of Master of Science*

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# Impact of Bridge 21 model on female students' confidence in STEM and Computing: Aligning the model to bridge the gender gap in STEM through a 21<sup>st</sup> century skills based intervention

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## 1. Chapter One : Introduction

### 1.1 Background and Context

There is a growing and passionate discourse about the need to address the gender imbalance in STEM and computing, both in Ireland and internationally. Countries with technology literate youth are not only likely to develop better, more robust economies but will also be able to deliver innovative solutions that can be influential on a global scale. It is therefore critical to train today's youth – which is now growing at an unprecedented rate to be equipped with the skills required to learn, lead and succeed in the 21<sup>st</sup> century economy. (Glinski, Weiss, Shetty, & Gaynair, 2013)

The absence of women from this movement therefore is both concerning and crippling. A quick look at the figures reveals how evident and concerning the situation is in Ireland itself. “While 50% of the academic staff at lecturer level are female, women comprise only 19% of full professorships. The figures for industry are very similar, with women comprising 40% of junior management positions and only 17% of CEOs. Disaggregated figures for STEM and E&CS are difficult to obtain but in 2015, only 25% of those working in Ireland's STEM industries were women. The numbers of women progressing to senior leadership roles in STEM are therefore significantly less.” (Daly, Farrell, & Grimson, 2017)

The term ‘leaky pipeline’ is often used to describe the progressive disappearance of women as they advance in their education and careers in the fields of STEM and Computing. While most of the efforts from tech giants, corporates, higher education authorities and governments are directed at enhancing retention of women at the later stages of the ‘Leaky Pipeline’, there is a pressing need to introduce reform at the school level where the number of women entering the first stage of the so called ‘Leaky pipeline’ is very small to begin with. (Dubois Shaik & Fusulier, 2015)

Technology is not just a significant part of today's workforce but can also positively influence student learning in the classroom. However technology is not well integrated into

many school curricula. This partly due to teacher's unawareness of how technology can be used to create an environment rich with creativity and inquiry and partly due to the fact that our education systems are wedded to an instructional approach which relies heavily on rote memorization. (Glinski, Weiss, Shetty, & Gaynair, 2013) In this paper we examine the role of 21<sup>st</sup> century skills in enhancing the confidence of women in STEM and Computing and subsequently their academic and career choice.

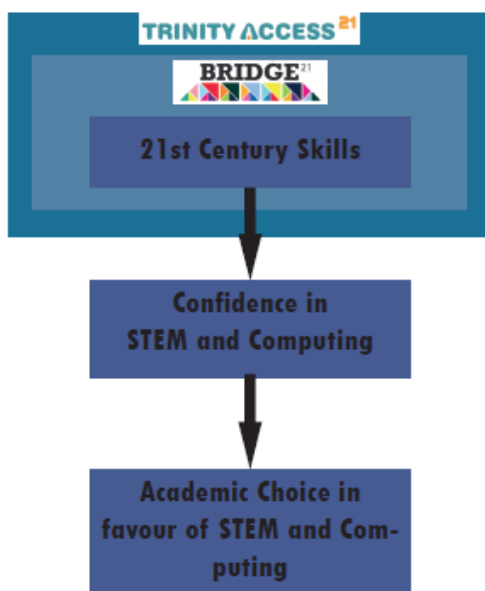
Trinity Access 21, here after referred to as TA21, is one such 21<sup>st</sup> century skills based programme which aims to encourage a strong, college-going culture through purpose driven intervention for secondary level Irish students. One of the ways that TA21 intends to reform the teaching and learning system is by training teachers to teach 21<sup>st</sup> century skills through the implementation of Bridge 21 - a team based, technology enhanced, project based learning model. This is done both through offering teachers places on the Postgraduate Certificate in 21st Century Teaching and Learning alongside Continuous Professional Development offered through partner schools. (O Sullivan, et al., 2016) Similar initiatives such as Intel Teach, a program which has trained more than 10 million teachers in over 70 countries to integrate technologies and project-based teaching methods into classrooms since its launch in 2000, have been found to have a significant impact on girls' confidence in the classroom. A focus on twenty first century skills, project-based learning with technology, problem solving, and collaboration has special relevance for girls who are more likely to face gender-related barriers that limit their voice, aspirations, and access to resources. (Glinski, Weiss, Shetty, & Gaynair, 2013). Another study at IOWA University establishes absolute links between girls interest in creativity, problem solving and design which are key elements of a 21<sup>st</sup> century classroom, as positive indicators of interest in all four disciplines of STEM. (Cooper & Heaverlo, 2013). In the context of STEM and Computing, confidence can be the difference between breaking the gender stereotypes and male dominance, or yielding to factors at play in the 'leaky pipeline'

## **1.2 Research Aims**

As discussed in the previous section building the confidence of female students through leading a change in teaching and learning attitudes is imperative at the secondary education level. ***This paper aims to study the impact of the Bridge 21, a learning model for effective***



**21<sup>st</sup> century team based learning on female students' attitude and confidence in STEM and Computing. We focus specifically on two factors - frequency and confidence in dealing with technology, attempting to identify the success of the TA21 and Bridge 21 model, as a tool to make female students more confident in their STEM and Computing acumen. The surveys were conducted with approximately 615 transition year students in TA21 partner schools. The results are compared for female and male students to measure the deviation, and modifications to the current model are suggested in order to bridge this gap and maximize the success of the model for increasing female student's confidence in STEM and Computing and consequently their academic choice.** While no direct and isolated correlations can be drawn between confidence in Computing and the choice of STEM based majors at third level education, studies suggest that confidence coupled with other variables (e.g., gender, minority status, and parental occupation) can be predictors of science, technology, engineering and mathematics and computing major choice. Students' confidence level in their academic abilities in related fields makes a significant difference in their initial STEM major choice. (Martin W. Moakler Jr., 2014)



**Figure 1: Core Research reasoning**

The research in this paper aims to identify the overarching reasons for the gender gap in STEM through a comprehensive literature review, and use these findings to inform modifications in the structure and delivery of the current Bridge 21 model, from an educator's perspective. While the factors influencing the absence and progression of

women in STEM and Computing fields operate in a complex fashion and are affected manifold by the student's background, studies have shown that self-efficacy beliefs subsequently influence academic and career choices for both men and women. (Zeldin, Britner, & Pajares, 2008).

Active intervention programs such as TA21 and Bridge 21, to enhance the confidence of girls in computing can swing academic choice in favour of STEM. The research can inform both educators and higher education authorities on best practises in organising and implementing STEM or Computing classes and advocates for Bridge 21 as a candidate learning model to positively impact the confidence of girls in these areas and consequently work toward bridging the gender gap in STEM in Ireland. With this aim in mind the paper will address the following questions.

### **1.2.1 Research Questions**

1. What is the impact of Bridge 21 model on female student's confidence in computing?
2. Could the Bridge 21 model be modified to improve the confidence of female students in computing?

The paper addresses the two primary research questions through the following steps –

1. Identify the fundamental reasons and solutions for the gender gap in STEM and Computing globally and in Ireland through a comprehensive literature review.
2. Looking at the main working pillars of the Bridge 21 model and examining what works well as well as the limitations.
3. Evaluating the results of the Trinity Access 21 study to inform the limitations of the current working model.
4. Using the findings of the literature review and the TA21 study to inform modifications and implementation guidelines in the Bridge 21 model which will positively impact the confidence of girls in STEM and Computing.

### 1.3 Structure of the Research Paper

The first chapter introduces the background and the context of the research. The main research questions that the paper intends to answer and the approach that it takes has also been outlined in the introduction.

1. Chapter Two presents an encyclopaedic list of factors affecting the confidence of female students in areas of Science, Technology, Engineering and Mathematics (STEM) and Computing negatively through existing literature on the subject and past studies on middle and high school female students. The terms STEM and Computing are used as general indicators of female student's ability to deal with scientific, technical, industrial or computing related fields. We also relate the reasoning from this literature review to the current figures of women in STEM and computing fields in Ireland through a gender based analysis of the Higher Education Authority's 2018 report on tertiary education. The findings from this section are also used to inform the modifications in the existing Bridge 21 model to make it more impactful to address these challenges.
2. Chapter three introduces the components of the Bridge 21 model and explores the core pedagogical concepts it is based on. This has been done in order to discern the components that can be improved on or supplemented. The final section of the paper refers back to these core building blocks of the model and suggests modifications to make it more effective and responsive to the confidence of female students in STEM and Computing with a view to positively affecting their academic and career choice in these fields.
3. Chapter four uses quantitative research methods to analyse the data from over 615 Irish transition year students who participated in the Trinity Access 21 study which recorded responses about the frequency and confidence of using technology in and outside the classroom in varied contexts. The programme is being run in partner schools through Trinity College Dublin. This quantitative research is used to establish how effective both the intervention of TA21 and participation of students in Bridge 21 workshops has been to improve the confidence of female students in STEM and Computing.

4. In the concluding section of the paper best practise suggestions are made for the core pillars of the Bridge 21 model and its delivery. These recommendations are based on the literature review in Part one and the results of the findings in Part two for teachers to positively impact girls' confidence in STEM and Computing.

## **2. Chapter 2 :Women in Computing - Confidence vs. Competence**

### **2.1 Literature Review**

STEM and Computing is and remains a heavily male dominated field until date in most countries with few exceptions to prove otherwise. While the female representation in other fields of STEM has seen some improvement, Computer Science is still an area that women are reluctant to venture into whether it is in academia or industry.

In this section we examine the situation of women in STEM and Computing in Ireland and in the global context as well. We will look at some of the factors, particularly those pertaining to the Secondary/ Post-Secondary education phase for female students and attempt to outline the factors affecting the choice to pursue a first degree in a STEM or Computer related field. These findings are used to inform the suggestions and implementation guidelines to the Bridge 21 model to enhance its impact on the confidence of girls in these fields.

The 'Leaky Pipeline' is a term used to refer to the loss of women in the field of technology at three main stages school, university and mid-career stage and is often used to refer to the progressive loss of women in the field of technology at three main stages. The first of these stages is the School Leaver stage where girls with a probable propensity for STEM choose not to pursue first degrees in related fields. The second stage develops just after university where women are unable to see their degrees to completion or decide to pursue a career in a non-technical field instead. The third stage called the mid-career stage refers to women who drop out of their careers after ten to fifteen years of being in the workforce. In this paper we primarily look at the first stage of the pipeline. (Blickenstaff, 2005)As outlined in the introduction, if the number of women entering the pipeline is very small to start with, there is little prospect to fixing it further down the line.

There has been extensive and noteworthy research done on the absence of women in STEM and Computing. Initial literature was obtained by looking at the current situation in Ireland and the initiatives that are in place at school, external and policy level to address the situation. To assess the situation in Ireland official reports from the education department, the European Commission were scanned to reveal useful insights. Further keyword based search was used to discern the interdependence of 21<sup>st</sup> century skills and STEM based career choices in girls. While some of these findings are presented strictly in an Irish context, a lot of the literature consulted to inform this section also draws on studies done with middle and high school female students in other European countries, United States as well as classroom based inquiry carried out by organisations such as Intel and Microsoft in developing countries. Despite the varying contexts, the fundamental reasons for girls' unwillingness to enter STEM and computing disciplines were concurrent across the literature and are highlighted in this section. It is also important to mention that these factors don't function in isolation at the first stage of the leaky pipeline alone and are often exhibited at multiple stages in women's involvement with STEM and Computing, resulting in a long term negative impact on the confidence of otherwise competent women.

The common thread running through the content referred to in the literature review predominantly deals with issues related to culture, classroom instruction, opportunities outside school hours and support from teachers and parents. An analysis of the recurrent reasons affecting the confidence of girls when dealing with STEM and Computing disciplines is presented below.

### 2.1.1 Lack of Social Context and Hands on Experience

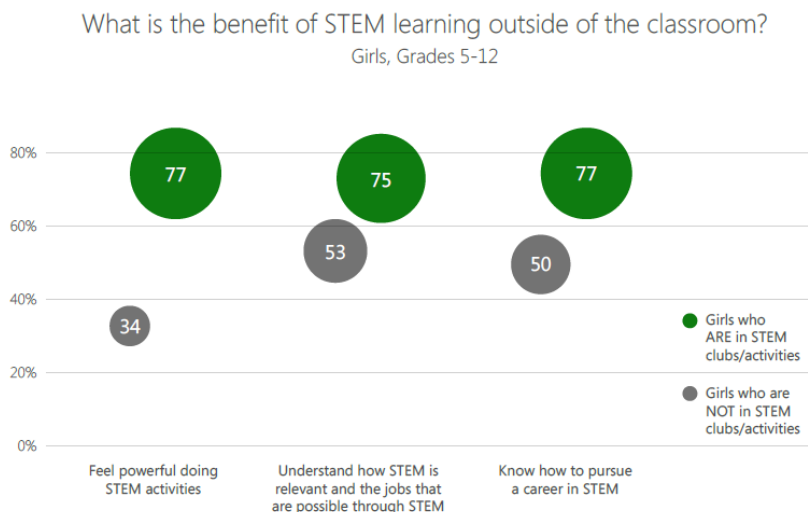
Often when dealing with technical subjects the approach that teachers tend to take is one of putting excessive focus on the technical aspects rather than a collaborative, task based style which focuses on building useful applications. In Fisher and Margolis 'Unlocking the Clubhouse' high school teachers affirmed to the 'dry abstract style' of teaching being one of the foremost reasons for girls not opting for Computer Science. (Margolis & Fisher, 2003)

The teaching, especially in the early stages tends to put too much emphasis on the technical details rather than building applications. The inability to see the bigger picture and the narrow view of what a career in technology tends to look like discourages many young

women whose primary reason for choosing technology is to tackle societal challenges through it rather than to solely attain mastery of the technical aspects themselves. (Appianing & Van Eck, 2015). A large majority of young girls consider it important that their job or career enable them to make a positive impact on the world. With the current view of teaching STEM and Computing topics, we are missing an opportunity to show young girls how meaningful and impactful these jobs can be. (Kesar, 2018)

This is further backed up by data obtained from professional networking site LinkedIn, which asserts that e-learning companies where the social function of technology i.e. education is apparent are very close to attaining gender balance in their engineering workforce. (Murthy, 2015) With this in mind, the way younger female students are introduced to computing at the high school level should focus more on collaborative application building which emulate, as closely as possible real world problems so students can see ICT as an “enabling tool for innovations in health, governance, communications, commerce, etc.” (Iclaves SL for the European Commission, 2013)

In addition to the positive shift in attitude towards a career in STEM that can be achieved by communicating the real world accomplishments of engineers, mathematicians and computer scientists, exploring and creating some of the applications first hand can also be a useful way to learn about social impact of Computer Science. According to the Microsoft study, “75 per cent of girls who participate in STEM clubs and activities understand the types of jobs they could do with STEM knowledge, compared to 53 per cent who do not participate in those activities. An even bigger difference comes through in their feelings of empowerment. Of girls who encounter STEM and computer science in the classroom alone, only 34 per cent feel powerful while engaging with STEM.” (Kesar, 2018)



**Figure 2: Microsoft statistics on providing hands on experience (Kesar, 2018)**

### 2.1.1.1 Opportunities for female students to participate in STEM and Computing Activities in Ireland

According to a study commissioned by the Science Foundation Ireland in 2014 on the factors influencing the choice of degree in first year students of their third level graduate courses, "fitting in" was cited as being very important to young people. While future earnings and career prospects were important in this decision making as well, these were secondary constraints. The students participating in the study affirm that they would not even seek information about a field of study if they fail to identify with the perpetuated stereotypes of a course or career. Encouragement from parents and teachers were also identified as influencing factors in their opinion of 'fitting in' or identifying positively with a chosen field of study (Science Foundation Ireland, 2016).

To this end, it is important that girls are given an opportunity at the primary and secondary education stage to engage with STEM and Computing related activities, both formally and informally, in order to have a positive influence on their confidence in studying these subjects at a university level.

Up until November of 2017, there has been no provision in the Irish school system for Senior Cycle students to study Computer Science. When girls have little opportunity to be exposed to computing in the formative years of their education it is no surprise then that very few female students opt for degrees in STEM or Computer related subjects. The Action Plan for Education 2017 recognizes the immediate need to introduce computing as a means to equip

students with the twenty first century skills required for jobs in the knowledge society. The department has committed to launch Computer Science as a subject in the Senior Cycle which will be implemented starting September 2018. Further to accelerate the Digital and ICT agenda in schools, a coding course for the Junior Cycle has also been proposed. (Department of Education and Skills, 2017).The forty participating schools represent a diverse set across the Republic of Ireland. Minister of Education and skills, Richard Bruton said announcing the new subject, “The introduction of this new subject will teach our young people flexible, solution orientated thinking. It will teach them to be creative, adaptable learners. It will increase the number of students taking up computing and STEM courses and apprenticeships after school leading to a highly-skilled workforce.” (Department of Education and Skills, 2018)

While this is unquestionably a step in the direction of encouraging female students to take up STEM in higher education, other contributing factors will need to be sensitively addressed while implementing the proposed Computer Science programmes in these forty schools and the Bridge 21 model provides a well – researched and documented model for teaching STEM and Computing amongst other key twenty first century skills.

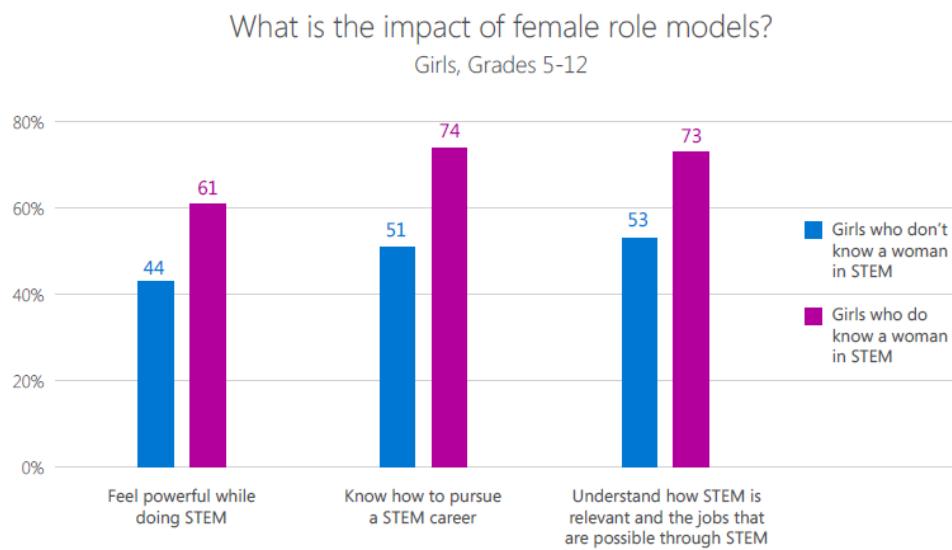
### 2.1.2 Lack of Role Models

When young women do not have successful industry leaders to look up to as role models for their preferred careers or within their network of friends and family, they feel naturally less inclined to choose these as their career options. Isolation remains one of the primary reasons for recruitment and retention of women in STEM and computing. Fisher and Margolis’s book describes Vera, an undergraduate student’s experience as one of feeling very isolated amongst her male peers. Vera notes feeling left out as a result of the male bonding and talking in her immediate peer network. (Margolis & Fisher, 2003)

The lack of industry role models and within students’ network of family and friends also results in a sense of isolation that further aggravates the problem. The European High Commission recommends improving the mainstream visibility of key female leaders in tech as an important measure to bridge the gender gap (Iclaves SL for the European Commision, 2013) . Schools can benefit from this suggestion by having female teachers for STEM and Computer Science as well as organizing informal industry interface events where students



get to interact with professionals and get first hand advice about career and life at the workplace. Such informal interactions with possible mentors can both help women make bolder choices when it comes to STEM as well as make them more comfortable with the idea of leadership in the field.



**Figure 3: Microsoft statistics on the impact of role models** (Kesar, 2018)

### 2.1.3 Male Dominated Environment and the Confidence Gap

Often the male dominated environment in STEM and Computing can be a deterrent to women feeling comfortable and a sense of belonging. Studies have confirmed that environments that are stereotypically ‘geeky’ and ‘masculine’ can force women to feel like they need to conform to these stereotypes, leaving them confused about their place in computing. (Fisher & Jane, 2002)

In addition to the stereotypes, different styles of communication, risk taking, competition and negotiation between the two genders can also lead to deterioration in the confidence of female students if they find themselves in male dominated environments. Studies establish that women are often significantly less self-assured than men, and that for success confidence is just as much a factor as competence. In Computer Science this can play a pivotal role in the initial stages as the learning curve to mastery of any concept or programming language is steep and prone to failure. Within an unsupportive environment, confidence is bound to suffer. (Kay & Shipman, 2014)

Clara Shih, a tech entrepreneur and board member of Starbucks at 29, says recounting of her experiences studying Computer Science at University, that she was convinced the courses she struggled with were easy for her male peers. Despite the fact that she went on to graduate with one of the highest GPA's in her class, she said she "felt like an imposter". Facebook COO, Sheryl Sandberg in her conversation with 'The Atlantic' confessed that, "There are still days I wake up feeling like a fraud, not sure I should be where I am." A 2003 study by psychologist David Dunning involving university students in STEM, clearly established that "men overestimate their abilities and performance, and women underestimate both. Their performances do not differ in quality." (Kay & Shipman, 2014)

#### 2.1.4 Girls only vs. Co- Educational schools

Further to these findings it has been speculated that co-educational schools or any other mixed setting for learning may actually be bad for girls, especially when it concerns with STEM or Computing studies. While unintentional, even the top tier schools fail to celebrate girl's achievements who face a constant struggle to have their opinions heard and taken seriously over rowdy boys. Girls in co-educational schools have been reported to feel the same pressures they do in workplaces, such as conforming to stereotypes and feeling the pressure to be more feminine and disassociating themselves with subjects that are considered boys only such as Computer Science. These pressures can impede girl's achievements. (Parmar, 2013)

Single sex schools can alleviate the adolescent peer pressure of putting too much emphasis on physical appearance, social status and peer interactions and instead put the emphasis back on academic learning. (Park & et al, 2011)

In interviews conducted in a Mathematics classroom by Streitmatter, girls reported not feeling a sense of ownership in co-educational classrooms. The presence of boys in class was perceived as being dominant, "Guys yell out the answer and want to give the answers. They take up a lot of attention. It's kind of like the whole class is spinning around that guy and not math". (Park & et al, 2011)

"Single-sex computer classes offer female students the educational advantages of learning in a comfortable, non-threatening classroom environment where they are encouraged to

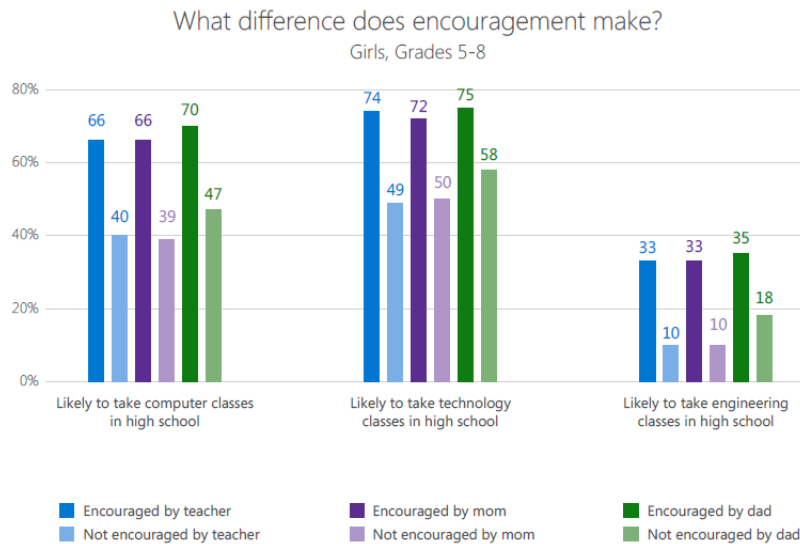
enthusiastically participate in classroom discussions and activities” (Swain & Harvey, 2002). Making girls only computer classes is a controversial, yet effective intervention that can lessen the gender gap in technology. While it is argued that such an approach is not effective to the end of preparing young students for the challenges of workplaces and university, it can be a temporary solution within co-educational spaces until educators can employ classroom management, teaching style and content that are sensitive to both boys and girls.

#### 2.1.5 Encouragement at home and school

In the 2018 Microsoft study of middle and high school girls’ attitude to Computer Science, more than half of the participants said they received encouragement from their mothers or teachers, but this number was low for the participants who received encouragement from their fathers to choose a career in STEM or Computing. (Kesar, 2018)

Support from fathers or other male role models within the family can have a significantly positive influence on the probability of their choice of study programmes at the first degree level, as with support from male role models they can trust, which breaks the unfavourable bias that certain fields are unwelcoming or unsupportive of females. This is not to say that encouragement from female teachers or mothers is not valuable or does not have a positive effect.

The study establishes that 66 per cent of girls who received support from both parents and teachers said they are likely to study Computer Science in high school. The numbers are slightly higher for girls who received encouragement from their fathers. (Kesar, 2018)



**Figure 4: Microsoft statistics on the impact of encouragement at home and school (Kesar, 2018)**

From an educator perspective, praising effort and reasoning rather than focusing on the correct answers can help overcome the confidence bias in girls. Often teachers can have internalized gender stereotypes that manifest in their interactions differently with boys and girls within the same classroom. “One of the biggest issues with how most people think about stereotypes—they think it’s intentional. But actually, if you don’t do anything, you will hold stereotypes, and it’s something you have to fight against, especially as educators.” (Ossola, 2014)

Research findings suggest that whole class discussions where the outcome of who contributes is determined by the teacher, boys can tend to dominate class and teacher time. Even within group work, boys are predisposed to be more vocal and hands on with the project work compared to girls. Furthermore, there is evidence that girls not only comply with such patterns but often help to create it. In mixed gender group work, both boys and girls tend to turn to boys for help. As educators, it is important to be aware of these interaction patterns and to and work actively to mitigate these biases in their own teaching practise as well as giving girls the necessary encouragement at all stages of the lesson. (Howe, 1997)

## 2.2 Gender at a glance at third level education in Ireland

As highlighted earlier in the literature review, some of the data and studies referred to in the previous section pertain to a more global context rather than strictly Irish. In

this section we map the reasons highlighted above to the current situation of third level education in Ireland.

The Higher Education Authority publishes useful insights about student enrolment data in its funded institutes which includes seven universities, fifteen institutes of technology and four part funded colleges. These institutes present a holistic picture of the third level education in Ireland and useful cognizance about the gender makeup amongst other factors. In this section we look at some of the key facts and figures from the 2016/17 report with a focus on gender. The segregation of the figures follows the method highlighted in Kennedy's (Kennedy, 2017) analysis of the 2014/15 report.

The total number of full time undergraduate new entrants for 2016/17 was 43,569, a figure that is 5% higher than five years ago, thus reflecting a continuing demand for higher education in Ireland. This comprises of students enrolled full time in both universities and Institutes of Technology, with a segregation of 53% to 47% respectively in both. One of the most significant distinctions in gender is that of the 225,628 total enrolments at both undergraduate and postgraduate level, 52% identify as females and 48% as males, a compelling difference.

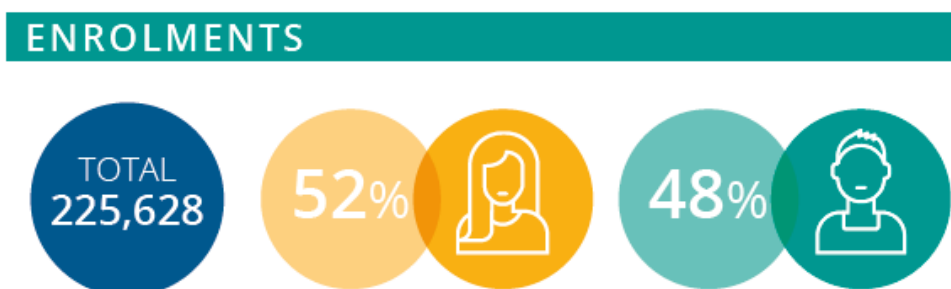


Figure 5: Gender make-up of the total enrolments in Irish Third level institutes ( Higher Education Authority IE, 2017)

At the undergraduate level, the difference is not that huge with the number of male and female students almost at par at 51% and 49%. This trend has remained consistent over the last five years. At the postgraduate level the numbers begin to deviate further with women making up a majority 55% of the total enrolments, a significant increase in number over the last five years compared to the consistent

trend observed at the undergraduate level. The number of women begins to show a decline at the postgraduate research level with only 44% of women working towards a Master’s Degree research. At the Doctorate level, the figures are comparable.

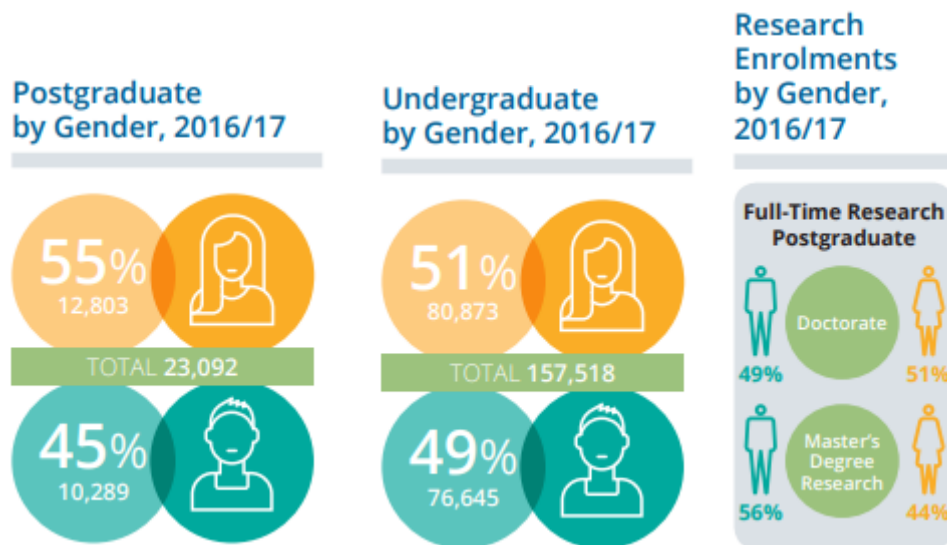


Figure 6: Gender make up of PG vs. UG fulltime enrolments ( Higher Education Authority IE, 2017)

**a. Variance in gender by institution type**

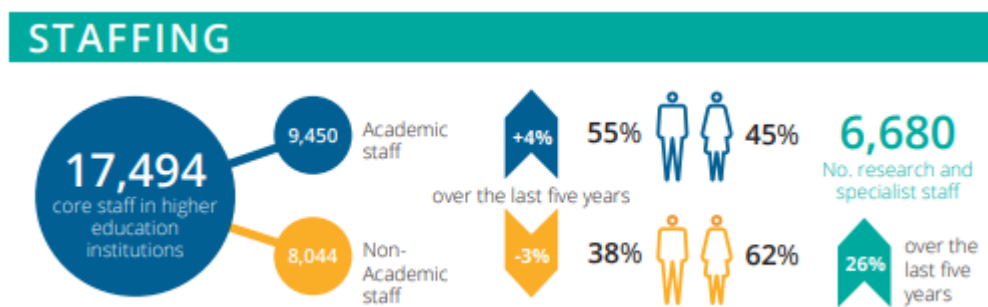
At a quick glance the number of students enrolled in third level institutes looks promising for women at 52% but there are acute differences when the numbers are compared for gender enrolment in universities versus Institutes of Technology with the latter being overwhelmingly male.

Compared to 74% and 55% female students in Colleges and Universities respectively, Institute of Technologies only comprise of 43.7% female students. (Higher Education Authority, 2017)

While there are a number of factors accounting for such a distinction, one of the more palpable reasons for this following our literature review is the fact that IoTs offer more Science, Technology and Computer based courses which are pre dominantly considered attractive fields of study for male students. Additionally, colleges have disproportionately female enrolments as they offer education courses, a field considered more appealing to women for its societal function. Colleges and universities often have more demanding application procedures and academic

requirements, which girls often tend to outperform boys in. (Kennedy, 2017) Furthermore, the social function of jobs associated with education courses is more apparent which as highlighted in our literature review is an important consideration for girls.

Gender disparities remain evident in staffing of academic as well as non-academic staff with women making up only 45% of Academic staff. The figure swings in favour of women in the non-academic staffing department with women making up 62% of the total staff.



**Figure 7: Gender make up of staff at Irish third level institutions** ( Higher Education Authority IE, 2017)

### b. Variance in Gender by Age

The principal revelation from analysing the data set by age is that the number of male and female students is proportionate in the range of 17-21. However the female figure starts to diminish as we move up the age distribution range. Only 40.3% of students aged 23 are female, between 25-29 the representation is at 45.7% with little improvement in other age brackets between 21 and 30+.

Looking back on the literature review and figures from the HEA on gender in the postgraduate community this doesn't seem to be due to fewer women choosing to pursue postgraduate studies. In fact women outweigh men by 5% in the postgraduate enrolled student numbers in Ireland. Based on this the statistics should have been in favour of women but it can be speculated that that more men choose to pursue undergraduate studies slightly later on in life, and make up a greater percentage of mature students. (Kennedy, 2017) While the issue of age is not a focal point of this study, it was both

important and interesting to note the remarkable difference in numbers. (Higher Education Authority, 2017). The receding figures can be further attributed to the fact that as women get older there is an increased cultural pressure to conform to traditional gender roles such as getting married or having children. (Blickenstaff, 2005)

### **c. Variance in participation across subjects**

Of all the factors influencing the number of female students at third level institutes in Ireland, the field of study presents the most interesting and distressing findings. A quick look at the percentage representation of women across different subjects reveals that Information and Communication Technologies along with Engineering, Manufacturing and Construction are the worst malefactors with women representing a trifling 15.6 and 16.7 % of all full time undergraduate enrolments in these fields. These numbers are also consistent with the conclusion of the literature review.

While these revelations aren't novel and are well documented, it is still surprising that despite the growing effort from higher education institutes and government, the situation remains dismal in 2016/17. Some individual fields of studies under Engineering and Manufacturing such as Architecture and Town Planning as well as Food Processing reveal numbers in favour of women but fail to affect the overall representation. These findings are consistent with the literature review which divulges that both ICT and Engineering remain heavily male dominated fields because of gender stereotyping, lack of role models and other key factors that are at play during the secondary level education in Ireland.

The fields of Natural Sciences, Maths and Statistics reveal a balanced overall picture but a closer look at individual fields swings numbers in favour of male students in Physics, Mathematics and Statistics with female numbers as low as 17.2%, 23% and 29%.

Fields with the highest representation of women are Education at 74.1%, Social Sciences, Journalism and Information at 62.76%, Health and Welfare at 77.2%. This further reinstates our findings in the literature review which state that women's choice of degree programmes is heavily affected by the social impact of their study and the ability to see the bigger picture at an early stage of education. (Higher Education Authority, 2017)

### **d. Key Takeaways from this Section**



Globally, 15 year old girls are two times less likely to aspire to a career as an engineer, a scientist or an architect and three times more likely than boys to expect to become health professionals. Consequently, there is no surprise if women account today for only 20% of tertiary graduates in ICT fields. (OECD, 2018)

While it is clear that the situation in Ireland is no different to the global context of the literature review, the statistics on the whole are eye opening. The overall gender balance in the number of full time university entrants is promising but the results are skewed in favour of men in the areas of STEM and Computer Science. Efforts to deconstruct these stereotypes and encourage women in these fields are laudable and must be sustained and improved in the future as in their current state they have remained largely ineffective. The statistics in the HEA study apply only to Ireland but the issue of acute gender imbalance manifests itself on a global stage and is a widespread cultural and grass root education issue. “We’re socialising women to believe they’re less suited to do maths and men to believe that entering childcare would be emasculating and beneath them. We all need to be challenging our assumptions about such things on a daily basis.” (Kennedy, 2017)

### 3. Chapter Three : Introduction to the Bridge 21 Model - Towards 21<sup>st</sup> Century Learning for Women

As argued in the introductory chapter about the need to equip young female students with the key twenty first century skills as a medium to positively influence STEM based degree choices, there is a need to establish a standardized learning model that facilitates the effective acquisition of these skills in a learner centred, team based approach. A 2016 report on the STEM education in Ireland affirms that there is a growing onus on teachers to incorporate 21<sup>st</sup> century skills in curriculum related to STEM disciplines as well as others, which have been determined to be critical at all stages of education. (Binkley, Erstad, Herman, Raizen, & Ripley, 2012)“Teamwork facilitates project based learning and when mediated with technology proves an effective partner in creating an engaging and autonomous learning experience” (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018). Studies on the effectiveness of the model in this context both in and outside of Irish schools form the backbone of presenting the Bridge 21 learning model as a “candidate learning model for effective, implementable, twenty first century, team based learning” (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018). In this section we look at the working pillars of the learning model which will help inform decisions about what modifications or additions need to be made to the current model for it to be more effective to address the gender based confidence gap in STEM.

#### 3.1 Core Pillars of the Bridge 21 model

- a. **Team Work:** Teamwork is at the core of the Bridge 21 model and all tasks are done in groups of three or four based on the overall size of the participating group. The model adopts the practise of Michael and Sweet’s injunction, where teams are formed using a random assignment method by the mentor. This is done in order to avoid students favouring to work with particular people based on personal relationships as well as to ensure that the teams comprise of diverse abilities and backgrounds. (Michaelsen & Sweet, 2008) Teams work together through progressively challenging tasks to meet the final objective. With the team students may assume roles such as Researcher, Coder, Writer, Multimedia and Creative Artist, Presenter based on the task at

hand. While these roles may vary, each team always appoints a Team Leader who is allowed to make changes in the project following the reflection stage. The leader is also responsible for relaying messages back and forth between the team and the mentor amongst others. (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018)

**b. Technology Mediated Collaboration :**

The use of computers or other appropriate technology to achieve the final objective is central to the Bridge 21 learning model. Developing confidence in dealing with unfamiliar technology or applications is recognized as a frequently required skill in jobs that are being created in our knowledge based economies. Team members teach themselves and each other to deal with technology or application they may not be accustomed to and in the process adapting to this independent process of learning. (Mitra & Quiroga, 2012)

Typically, a team of four members is equipped with two computers to enhance collaboration and to avoid students feeling left out and frustrated whilst dealing with challenging tasks. (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018)

**c. Learning Space :**

The rationale behind having a special space for team based learning is that the environment and décor reflect back the sense of working together to achieve goals that are important, not just as a lesson aim but as wider, real life like problems that students will likely be tasked with in real world jobs.

The Bridge 21 learning space can be divided into three main areas. The 'team pods' are confined, private working spaces for each team with computers as their resources. Usage of swivel office chairs reinforces the sense of being in an office like setting. The 'breakout areas' allow for teams to have a meeting space in order to resolve any disruptions or issues they might be facing within their groups. These can also be used as meeting areas to brainstorm and make action plans in conjunction with all team members. The 'Presentation

Area' is where each team presents their final work to the other teams in the penultimate stage of a Bridge 21 lesson. (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018)

d. **Project Based Learning**

The final task in a lesson based on the Bridge 21 model often requires the production of an artefact or presentation. The process of creation is layered, progressively complex and models real life problems as closely as possible. (Savery & Duffy, 1995) The process of creation requires both collaborative and individual work, is time bound and offers an opportunity for students to reflect on their final product and presentation. The role of the mentor through this process is to guide rather than to instruct. (Thomas, 2000)

e. **Team and Individual Reflection**

Team and self-reflection form an integral part of the Bridge 21 model. This is the final stage of the lesson where students get a chance to reflect back on the process and outcomes of the lesson in order to reinforce cognitive learning and higher order thinking in accordance with learning taxonomies such as Bloom's Taxonomy. (Dewey, 1933) .This stage of the lesson may be supported by open ended questions, surveys or writing that enable personal reflection. (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018)

f. **Mastery Goal Orientation**

Contrary to traditional classroom and assessment models where pupils compete with each other and performance on a particular task or subject is measured in relation with other students, Bridge 21 aims to foster intrinsic motivation by avoiding these normative assessment practises. (Lawlor, Marshall, & Tagney, 2016) The goal is shifted from achieving 'mastery' by gaining superiority over others to working together to learn and achieve a task. (Chiaburu, 2005). The obvious benefit of a non-competitive learning

environment is that it takes the emphasis from outperforming others to individual performance and contribution to the team's task.

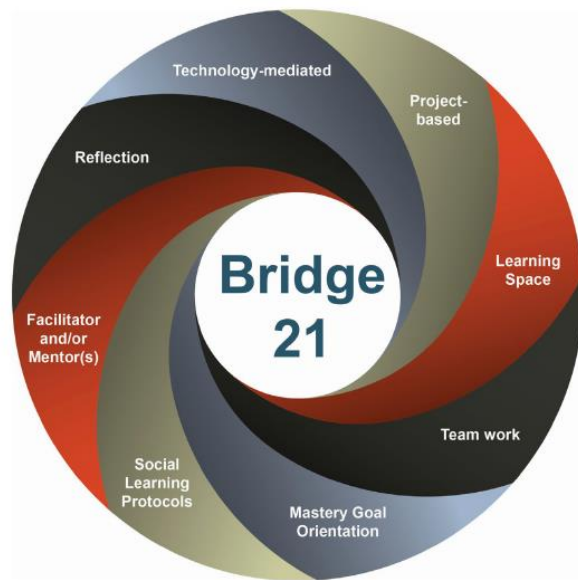
Elements of competitiveness during the presentation stage are downplayed to favour the core spirit of inter team co-operation and critique rather than emerging as the best. (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018)

**g. Social Learning Environment**

Contrary to most schools in Ireland students participating in a Bridge 21 workshop are not mandated to wear uniforms. Pupils are encouraged to address mentors by their first names to permeate a sense of collaboration with the mentor rather than that of establishing authority. Discussion, talking and collaboration are encouraged rather than repressed. The design of the learning space itself lends well to distinguishing it to the emblematic idea of a high school in Ireland (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018). These practises are incorporated to support and social and constructivist pedagogical practice. (Blatchford, Kutnick, & Galton, 2003)

**h. Mentor / And or Facilitator**

In the Bridge 21 model, the adult supervisor acts as a mentor whose primary role is to set up the tasks, introduce students to the necessary media / technology and provide support, but not solutions to the teams. The mentor acts in a manner where the decision making process and outcome of the projects are primarily handled by the students with minimal mentor intervention. (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018) This idea of 'taking a step back' so that the students 'step up' derives from Vygotsky's Zone of Proximal Development where learning within and from each other in small teams, in a social constructivist learner centred sense is central to the model. (Vygotsky, 1978)



**Figure 8: The Bridge 21 working model** (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018)

## **2.2 Situating Bridge 21 and Trinity Access 21 in the Irish Education System – Implementation and Impact**

Education is compulsory in Ireland from the age of six to sixteen or until students have completed three years of second level education. The Irish Education system comprises of Primary, Second Third level and further education. Parents can enrol children in state funded or private schools.

Most of the participating students in the Bridge 21 programme are Second level students which is the Post Primary phase. Institutions at the Second level comprise of secondary, vocational, community and comprehensive schools. In the context of Bridge 21 implementation we will mainly look at the Second level phase. Students starting Second level education are typically twelve to thirteen years old. Second level education comprises of a three year Junior Cycle followed by a two or three year Senior Cycle. The graduating exam for the Junior Cycle, called the Junior Certificate Programme is taken after three years. Students who have finished the Junior Cycle can appear for one of the three two year Leaving Certificate programmes in conjunction with the type of Second Level School they have been enrolled in i.e. the Established Leaving Certificate, the Leaving Certificate Applied and the Leaving Certificate Vocational Programme. Between the Junior and Senior Cycle (Leaving Cert) students have the option of enrolling in a Transition Year Programme. Based

on their school policy it may be optional or mandatory for students. . Designed to act as a bridge between the Junior cycle and Leaving Certificate and with the overarching view of preparing students for more independent work and study, this programme is implemented independently by the schools based on the needs of the students and the guidelines set by the Department of Education and Skills. (Citizens Information , 2013) During the transition year students can ‘participate in learning strategies which are active and experiential and which help them to develop a range of transferable critical thinking and creative problem-solving skills.’ (Department of Education and Sciences, 2013-14)

Originally developed as a university outreach programme in schools of lower socio economic status, Bridge 21 since it’s foundation in 2007 has been extended and implemented in both large and small scale deployments made in partnership with second level schools across Ireland. Deploying the model on a wide scale incorporated getting schools to concede students who would participate in volunteer and expert led sessions which were offered in the Bridge 21 classroom as well as off campus on school location. Over the eight year period students in excess of 8000 have been enlisted for participation in the programme. (Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018). The Bridge21 model of team based, technology-mediated learning offers a pragmatic model for 21st century teaching and learning which has been trialled and its merits evaluated in an out-of-school setting and is now, through TA21, being deployed in schools. (O Sullivan, et al., 2016)

#### **4. Chapter 4 : The Trinity Access 21 Study**

##### **4.1 Context of the Research and Study Participants**

There are various structural barriers to the educational development of low Socio Economic Students, including access to information about further education options; educational guidance being replaced by counselling for critical personal issues; access to available trusted role models from similar communities who have progressed to higher education; and learning environments that tend to be teacher, rather than student—directed. The Trinity Access 21 (TA21) project is an initiative led by Trinity College Dublin that is working to address this inequality. TA21 was established in 2014 with support from Google Ireland and is a collaboration between the Trinity Access Programmes (TAP), Bridge21, the School of

Computer Science & Statistics and the School of Education, Trinity College Dublin. Trinity Access 21 is a manifestation of Trinity College's commitment to innovative educational outreach, expressed in the 'Engagement with Society' theme of the current Strategic Plan. It is a partnership to develop and disseminate engaging, innovative, inspirational educational models, grounded in research and advocacy. (O Sullivan, et al., 2016)

Primarily, the TA 21 programme is aimed at supporting schools, particularly those classified as low Socio Economic Status (SES), to build a strong college going culture, where high aspirations are the norm and there is a more active, engaged, teaching and learning environment.

Trinity Access 21 (TA21) partners with schools in disadvantaged areas of Ireland, aiming to prepare students to make informed post-secondary educational choices and to support them to realise their full educational potential. To meet these aims, TA21 helps schools develop four 'core practices':

- (1) 21st Century Teaching & Learning (21CL): Teachers are encouraged to integrate 21<sup>st</sup> Century Learning in their classrooms and develop their students' 21<sup>st</sup> Century skills (e.g. communication, collaborative, technical and problem solving skills). The Bridge 21 model of cross-curricular, technology-mediated, team and project-based and student-led learning underpins this practice. To date, this pillar has primarily been supported by offering teachers working in partner schools places in the Postgraduate Certificate in 21<sup>st</sup> Century Teaching and Learning, and through the provision of some (limited) in-school professional development.
- (2) Mentoring: Students are paired with trustworthy role models to cultivate good relationships and share important college going information.
- (3) Pathways to College: Students are provided with information about college options, the application process, and financial supports; this includes visits to college campuses and career networking events.
- (4) Leadership through Service: Students are put in charge of designing, planning and delivering a community service project. They develop leadership and project management skills.

The TA21 project began in 2014 and has tracked the educational outcomes of 1,100 students from 11 schools involved. The data reveal positive impacts on whole school culture



and is increasing college going aspirations in students. Three of the four core TA21 practices are drawn from the College for every Student (CFES) framework. This is an American non-profit organisation that uses the Mentoring, Pathways and Leadership pillars.

#### **4.1.1 Implementation of the Twenty First Century Learning Pillar: Situating study participants within the TA21 and B21 framework**

While the three CFES pillars have been consistently implemented in the schools, the development of the fourth pillar of 21<sup>st</sup> Century teaching and learning has been somewhat less systematic. This could be due to the fact that Mentoring, Pathways and Leadership are more directly student-focused, and facilitation of these pillars in schools has been strongly supported by the TCD schools team. Since the TA 21 intervention began in 2014, over 200 teachers have completed, or are taking modules, in the Postgraduate Certificate in 21<sup>st</sup> Century Teaching and Learning. One hundred and fifty students on Trinity's teacher training degree (Professional Masters in Education) completed a module in 21st century learning with technology. Teachers who have received this Continuous Professional Development through their association with TA21 report more use of collaboration and technology-mediated learning in the classroom. (O Sullivan, et al., 2016)

The participants of the study who responded to the questionnaire are from the partner schools where TA21 programme is being implemented. 1,100 students in the eleven project schools have completed year one of the structured three year project which has included visiting college campuses, completing career planning assignments, leading social change and structured mentoring sessions. For the study in this paper 615 students in TA 21 partner schools responded to the questionnaire measuring their confidence and frequency in dealing with technology in a variety of contexts. Of the 615 participants, 344 were girls.

The TA21 intervention objective was that through the provision of Continuous Professional Development in 21<sup>st</sup> Century Learning, both certified and in-school, the teachers would begin to integrate these practices into their teaching, and thus the level of confidence in STEM and Computing of the female students would increase. The study in this paper focused on the questions relating to the following two main parameters-

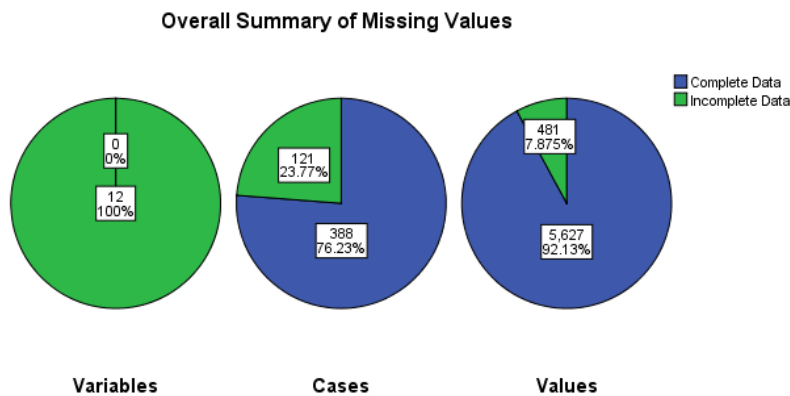
- Frequency of using technology in or outside the classroom

- Confidence in using technology

The responses to these questionnaires were compared for boys and girls to measure the deviation if any. Results from all girls versus mixed schools have also been compared and the findings are presented in the subsequent sections.

#### 4.2 Summary of Missing Values

The questionnaire comprised of twelve questions or variables which were measured for a sample set of 615 students (cases). Of the total 615 respondents (cases), 23.77% were received with some missing values. An overall summary of the missing values from the data set is represented in the figure below.



**Figure 9: Summary of Missing Values**

To provide a small element of context each question was coded as follows

**ks** = Key Skills **conf**= confidence **freq** = Frequency, Number = Questions number. For example **ks\_conf\_12** would be key skills question number 12 measuring confidence and **ks\_freq\_12** would be key skills question number 1 measuring frequency. Questions 1, 2, 10, 11, 12 & 34 all related to the technology construct so these are the ones that have been analysed. Some of the questions had relatively high percentage missing therefore; decisions had to be made about how to handle this missing data. A process called multiple imputations was used.

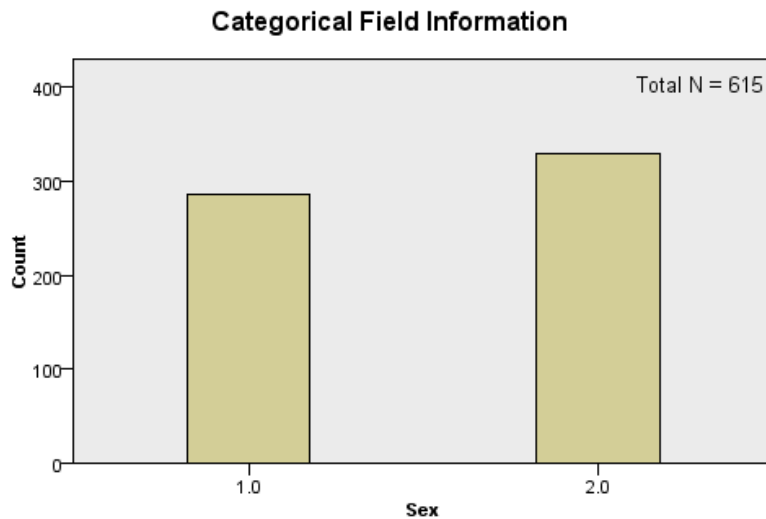
#### Variable Summary

	Missing		Valid N	Mean	Std. Deviation
	N	Percent			
Ks_Freq_34	91	17.9%	418	3.51	1.067
KS_Conf_34	62	12.2%	447	3.95	.977
Ks_Freq_12	59	11.6%	450	3.17	1.021
Ks_Freq_10	57	11.2%	452	3.00	1.065
Ks_Freq_11	56	11.0%	453	2.74	1.065
Ks_Freq_2	38	7.5%	471	2.46	1.175
Ks_Freq_1	28	5.5%	481	3.16	.957
KS_Conf_12	27	5.3%	482	3.78	.992
KS_Conf_11	24	4.7%	485	3.42	1.051
KS_Conf_10	22	4.3%	487	3.64	.949
KS_Conf_2	13	2.6%	496	3.43	1.059
KS_Conf_1	4	0.8%	505	3.83	.942

In order to handle the missing data efficiently multiple imputation was used. Higher Education Research involving missing data must employ techniques to handle these values. An appropriate method may be selected based on the nature of the missing values such as sample size, proportion of missing data, method of analysis etc. (Cheema, 2014) Multiple imputation is considered more effective than listwise deletion by many statisticians, which has been a frequently used method for educational research. In this context Multiple Imputation was established to be an efficient method for handling missing data. (Manly & Swells, 2014)

#### 4.3 Confidence and Frequency: Boys v Girls

The case values for from the data set were segregated into two sets. The total count and distribution of the two sets is represented in the figure below



**Figure 10: Categorization of data set into male and female**

1.0 = Male

2.0 = Female

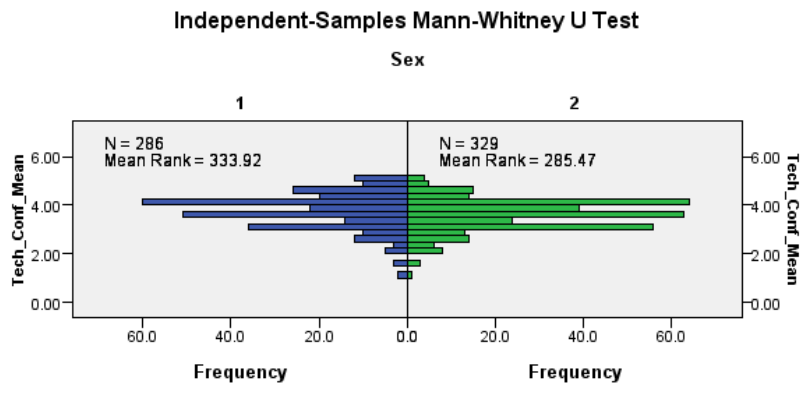
The values corresponding to each of these sets for the two parameters i.e. frequency and confidence were compared to measure whether the TA21 intervention in partner schools and technology mediated teaching and learning through the implementation of Bridge 21 has made a positive impact on frequency and confidence of dealing with technology for girls. In order to test for differences between the groups a test called a Mann-Whitney was used to compare the MEDIANS of the two groups i.e. males and females across the TA21 schools. The reason for this over a t-test was because there were some outliers found in the data and this test is less sensitive to outliers and therefore more appropriate in this situation. The t-test is a comparison of the mean whereas this test compares the distribution of the scores for each group. The mean distribution intends to provide a resolution for the following null hypotheses statements pertaining to our two main variables

–

- i. The distribution of tech\_confidence\_mean is the same across categories of sex.

- j. The distribution of tech\_frequency\_mean is the same across categories of sex.

The mean distribution results and the subsequent decisions for the null hypotheses are represented below:



Total N	615
Mann-Whitney U	39,633.000
Wilcoxon W	93,918.000
Test Statistic	39,633.000
Standard Error	2,192.712
Standardized Test Statistic	-3.381
Asymptotic Sig. (2-sided test)	.001

Figure 11: Mean confidence and frequency distribution for boys and girls

Report				
Imputation Number	Sex		Tech_Conf_Me an	Tech_Freq_Mea n
5	1	N	286	286
		Median	3.8333	3.0000
	2	N	329	329
		Median	3.6667	2.8765
	Total	N	615	615
		Median	3.6667	3.0000

Figure 12: Table displaying the median values for both genders in both confidence and frequency

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Tech_Conf_Mean is the same across categories of Sex.	Independent-Samples Mann-Whitney U Test	.001	Reject the null hypothesis.
2	The distribution of Tech_Freq_Mean is the same across categories of Sex.	Independent-Samples Mann-Whitney U Test	.035	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

### Confidence Interpretation:

A Mann-Whitney U test was run to determine if there were differences in Confidence when using Technology scores between males and females. Distributions of the confidence when using technology scores were similar, as assessed by visual inspection. Median confidence when using technology scores were statistically significantly higher in males (3.83) than in females (3.67),  $U = 39,633, p = .001$ .

### Frequency Interpretation:

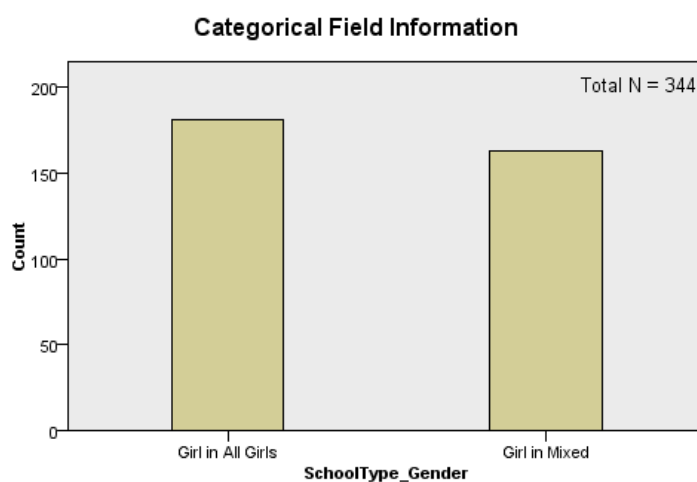
A Mann-Whitney U test was run to determine if there were differences in frequency using Technology scores between males and females. Distributions of the frequency using technology were similar, as assessed by visual inspection. Median frequency using technology scores were statistically significantly higher in males (3.00) than in females (2.88),  $U = 42,420.50, p = .035$ .

**Conclusion:** The distribution of the scores are *statistically significantly* different between males and females, with males exhibiting higher medians than females. This is true for both confidence and frequency.

### 4.4 Confidence and Frequency: All Girls v Mixed Schools

In the final point of our literature review it has been suggested that girls only computer classes is a controversial, yet effective intervention that can lessen the gender gap in technology. While it is argued that such an approach is not effective to the end of preparing young students for the challenges of workplaces and university, it can be a temporary solution within co-educational spaces until educators can employ classroom management, teaching style and content that are sensitive to both boys and girls.

Following these findings, the case values for from the data set were segregated into two sets. The total number of cases for the data set and their distribution is represented below

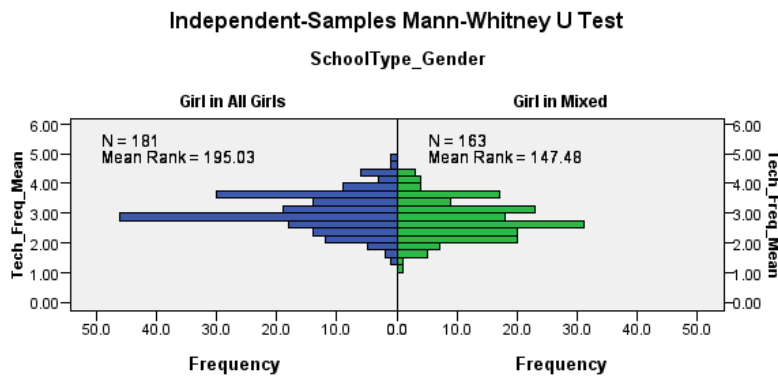


**Figure 13: Categorization of female student’s data set into all-girls school and mixed gender**

- a. Girls only schools
- b. Mixed / Co-educational schools

The values corresponding to each of these sets for the two parameters i.e. frequency and confidence were compared to measure whether there are significant differences in females enrolled in girls only schools to those enrolled in mixed or co-educational schools. Again, Mann-Whitney was used to compare the MEDIANS of the two groups across the TA21 schools. The mean distribution intends to provide a resolution to the following null hypotheses statements pertaining to our two main variables –

- a. The distribution of Tech\_Conf\_Mean is the same across categories of SchoolType\_Gender.
- b. The distribution of Tech\_Freq\_Mean is the same across categories of SchoolType\_Gender. The mean distribution results and the subsequent decisions for the null hypotheses are represented below.



<b>Total N</b>	344
<b>Mann-Whitney U</b>	10,673.000
<b>Wilcoxon W</b>	24,039.000
<b>Test Statistic</b>	10,673.000
<b>Standard Error</b>	919.426
<b>Standardized Test Statistic</b>	-4.436
<b>Asymptotic Sig. (2-sided test)</b>	.000

**Figure 14: Mean confidence and frequency distribution for girls in all-girls school vs. girls in mixed schools**

This is a more detailed view of the test. As we can see the distributions are similar shape. As they are similar shape we can compare the medians.



Imputation Number	SchoolType_Gender		Tech_Conf_Me an	Tech_Freq_Mea n
5	Girl in All Girls	N	181	181
		Median	3.6667	3.0000
	Girl in Mixed	N	163	163
		Median	3.5000	2.6667
	Total	N	344	344
		Median	3.6667	2.8443

Figure 15: Table displaying the median values for both genders in both confidence and frequency

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Tech_Conf_Mean is the same across categories of SchoolType_Gender.	Independent-Samples Mann-Whitney U Test	.010	Reject the null hypothesis.
2	The distribution of Tech_Freq_Mean is the same across categories of SchoolType_Gender.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

#### Confidence Interpretation:

A Mann-Whitney U test was run to determine if there were differences in Confidence when using Technology scores between girls in all girls schools and girls in mixed schools. Distributions of the confidence when using technology scores were similar, as assessed by visual inspection. Median confidence when using technology scores were significantly higher in girls in girls only schools (3.67) than in girls in mixed schools (3.5),  $U = 12385.5$ ,  $p = .01$ .

#### Frequency Interpretation:

A Mann-Whitney U test was run to determine if there were differences in frequency using Technology scores between girls in all girls schools and girls in mixed. Distributions of the frequency using technology were similar, as assessed by visual inspection. Median frequency using technology scores were statistically significantly higher in girls in girls only schools (3.5) than in girls in mixed schools (2.67),  $U = 10673$ ,  $p < .01$ .

### **Conclusion:**

The distribution of the scores are *statistically significantly* different between girls enrolled in girls only schools and those enrolled in mixed schools with the girls only schools exhibiting higher medians than mixed. This is true for both confidence and frequency.

## **4.5 Conclusions from the Data Analysis and next steps**

Based on the conclusions from the tests run to compare gender differences in confidence and frequency in using technology, it is clear that the TA21/B21 intervention in partner schools has indicated the inadequacy of the model in itself to suitably address the gender gap in computing in the partner schools. Statistically significant mean differences for the two variables and higher values for boys implies that girls are still less confident in comparison despite increased exposure to twenty first century technology mediated teaching and learning practises, amongst the three other core pillars of the TA21 programme. There are no previous values to compare these results to so it cannot be said with certainty if the overall confidence and frequency has seen an improvement since the TA21/B21 intervention began.

It is also interesting to note that students from girls only schools display higher average means than those in mixed schools.

### **4.5.1 Limitations of the Data analysis and Conclusion**

a. Through implementing the first pillar of the TA21 model, the TA21 surmises that the teachers participating in Continuous Professional Development and the ones who have been

offered places on the Post Graduate Certificate in 21<sup>st</sup> Century Learning are implementing the Bridge 21 framework and guidelines in their classroom practise. Although some of the students responding to the questionnaire have participated directly in workshops in Bridge21, the majority of them have not. For the purpose of keeping the research conclusion within the threshold of 21<sup>st</sup> century teaching and learning practise, suggestions have been made in the concluding section about modifications to the individual stages of the Bridge 21 learning model and its implementation in the classroom. These recommendations are based on the findings of the literature review which identifies the main factors hindering the confidence of women in STEM and Computing fields and the findings presented in the TA21 study.

**b.** While no polar conclusions can be drawn from the results about the effectiveness of a single gender learning environment, as it is dependent on a myriad of factors, there have been studies which advocate the isolation of Computer Science or coding classes for girls. Programmes such as Code Plus at Trinity College Dublin and their successful implementation goes on to further reinforce these findings.

**c.** Moving forward, the paper suggests some modifications to the individual stages of the B21 learning model in an all-girls classroom. These suggestions are based purely on the findings of the literature review and should be treated as provisional recommendations for educators and schools implementing the model. Some of the recommendations made are implementation guidelines whereas others are supplemental in nature.

## 5. Chapter 5 : Conclusion

### 5.1 Suggested modifications in the Bridge 21 framework



(Lawlor, Conneely, Oldham, Marshall, & Tagney, 2018)

Having looked at the literature review which provides the reasons for the lack of engagement from girls in STEM and Computing and the findings of the TA21 study which indicates that the model in itself has been ineffective to address these problems at the

secondary level, we use these as the groundwork to provide some suggestions for educators, schools and partner schools implementing Bridge 21.

These suggestions have been made with the intent of engaging girls in STEM and computing related subjects. While these are especially relevant for girls as they target the factors that limit the female representation, they are applicable to boys as well.

#### a. Teamwork

Team based learning where small groups work together toward achievement of a task with technology as a mediating medium can have significant social and academic gains. However, studies also suggest that the group composition and individual interactions are important factors in determining the quality and outcome of the interactions.

“Most of the small group studies have shown that while females and males in same-gender groups are equally involved in the verbal activity, especially in task-related interactions, males tend to dominate the verbal activity in mixed-gender groups”. (Lee, 1993). In order to outclass this phenomena and give girls a safe environment for free expression of thought, creativity and inquiry, it is suggested that when assigning groups for the task mentors make sure that the group gender composition is either balanced or ideally, all girls. In mixed gender groups girls also tend to make more peer comparisons and tend to form a negative view of their abilities. Self-efficacy as we established, is a significant factor in subsequent academic and career choice.

Another dedicated study on the gender differences in computer mediated communication and learning suggests that it is necessary to ‘explicitly address inclusiveness as an aspect of a collaborative classroom culture’ to avoid gender stereotyped participation and communication patterns. (Prinsen , Volman, & Terwel, 2006)

There is a challenge for teachers to manage such a situation but is important nonetheless to empower girls’ voice and expression in teamwork. (Humphreys, 2014)

The figure below summarizes the suggestions for the Teamwork pillar and the issues related to the gender gap in STEM and Computing that it targets.

1. All girls groups or gender balanced groups in collaborative work.

2. Explicitly addressing inclusiveness as an aspect of the classroom culture.

3. Avoid gender stereotyped participation and communication-patterns.

Male dominance.

Insights from data about all girls school.

### b. Technology Mediated Collaboration

Regardless of the gender composition of teams in the Bridge 21 framework, the use of technology to achieve a collective outcome can result in a number of classroom management related issues. The natural question that then arises is that if all participants are benefiting equally from the technology mediation. Fair availability of ICT resources for both boys and girls, 'establishment of rules and procedures, support of ICT-based activities by non-ICT and ICT tools, and division of labour among participants' are amongst some of the strategies suggested for a conducive learning environment. (Cher & Ching, 2013)

Teachers should conduct early interventions to identify the peripheral participants and take measures to help them become more active members in collaborative learning. (Prinsen , Volman, & Terwel, 2006)

The nature of the technology used can also determine the engagement and participation of girls. "Girls appear to be particularly interested in interactive technology that encourages communication, collaborative learning, the solving of complex social dilemmas, intensive writing and flexible problem solving" (Prinsen , Volman, & Terwel, 2006). For example, girls may be more interested in building a simple chat platform as opposed to a graphics based game.

Teachers and curriculum writers should start by examining girls current use of technology in their daily lives and use that as a starting point to 'redefine technological skill and use' . (Weber & Custer, 2015)

Occasional, Bring Your Own Technology initiatives such as the one being implemented at Clayfield College, Australia, can be organized in addition to the regular B21 workshops where students are asked to propose their own solutions to the given task through a technology of their choice. This can be a useful way for teachers to gain insights into the

tools or applications that girls are already using in addition to promoting self-direction in learning and making girls information producers rather than consumers. (The Alliance of Girls' Schools, 2013)

The figure below summarizes the suggestions for the Technology Mediated Collaboration pillar and the issues related to the gender gap in STEM and Computing that it targets.

1. Fair availability of equipment and equal division of labour.	Male dominance.
2. Identify peripheral participants and support them.	Confidence gap.
3. Bring Your Own Technology initiatives for girls.	Providing social context.
4. Use technology that encourages communication rather than ones that focusing on attaining technical mastery.	

### c. Learning Space

Further to narrowing the confidence gap between boys and girls when dealing with technology, the Bridge 21 model can be extended to adopt a flipped classroom approach where students can engage with the content and technical knowledge of the subject through videos, tutorials amongst other forms of digital media. This gives all students the flexibility to learn in their own time and leads to a more inclusive space where everyone has had access to the same resources which are essential for succeeding at meeting the task, in addition to preparing girls for a 'more active, applied learning of the content in the classroom'. (Department of Education - USA, 2016)

"Early research on flipped learning suggests students benefit from this approach with respect to improved test scores, course completion rates, and attitudes toward learning" (Hamdan, Mc Knight, Mc Knight, & Arfstrom, 2013) . Learning spaces supported by online teaching tools and adaptive learning solutions, afford both teachers and students a great deal of flexibility in structure, fair access to equipment. It should be noted that these suggestions are made for pre lesson engagement with the course or subject material with a view to bringing boys and girls at par in terms of subject and technical knowledge and subsequently bridging the confidence gap. With such an approach girls can be active participants to the group's activities rather than being passive observers and/ or seeking help from male peers which is also a common pattern reported in the study of interaction patterns in mixed gender groups.

One way teachers can help dispel myths about boys being more technologically inclined, is by introducing students to historical and contemporary role models in STEM. Drawing on the points from the literature review in Chapter Two about the positive impact of female role models on girls' self-perception and ability to imagine themselves in a STEM or ICT career, the physical classroom environment can be used to display both male and female role models in the form of posters or interactive displays. Exposure to women leaders can also be enhanced through films, guest speakers and class assignments. (Wiest, Strategies for Educators to Support Females in STEM, 2014) It is equally important for boys to be introduced to females in STEM as well to positively influence their perception of women in these fields as well as the notions that they project outside the classroom. (Wiest & Johnson, 2005)

The figure below summarizes the suggestions for the Learning Space pillar and the issues related to the gender gap in STEM and Computing that it targets.

1. Flipped classroom approach to help girls prepare and perform.	Confidence Gap
2. Introduce girls( and boys!) to historical and contemporary role models in STEM.	Lack of Role Models
3. Exposure to role models through posters, film, guest speakers from industry.	Providing hands on experience

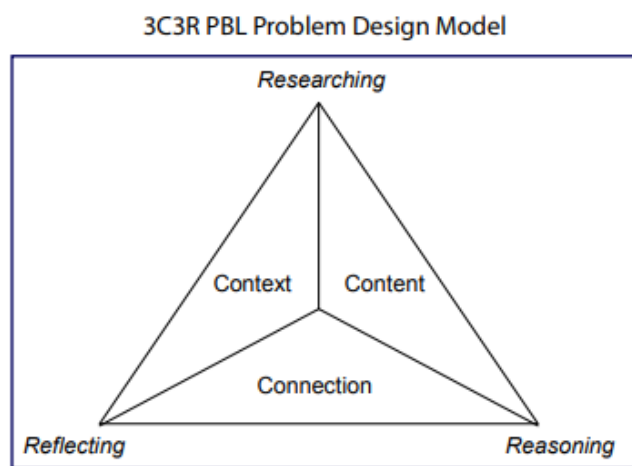
#### d. Project Based Learning

As a pedagogical instrument, Project Based Learning has been documented to have a positive effect on the intrinsic motivation, interest and student's belief about their abilities in STEM and Computing careers and majors. A Chicago University study on the Role of PBL on Motivation and Ability Beliefs and their subsequent interest in pursuing a career in STEM and Computing highlights the 'important potential of PBL for increasing student STEM attitudes and interest in future STEM careers.' (La Force, Noble , & Blackwell , 2017)

PBL's constructivist nature geared toward engaging students in democratic and multidisciplinary learning through finding creative solutions to real life problems is especially relevant for girls as exposure to real-world applications of STEM knowledge dramatically changes their outlook. ( Microsoft Whitepaper, 2017). In contrast to boys who are primarily

interested in how things work, girls take a keen interest in environmental, social and applying their knowledge to social conditions, all aspects that are taken into consideration in the PBL framework of lesson design. (Weber & Custer, 2015). Tasks or problems can define the success of each individual workshop and therefore elicit a high degree of care in both design and delivery. In a study investigating the match in instructor's intended objectives in designing a problem and student interpretation of the problem was only 64%. (Hung, The 3C3R Model: A Conceptual Framework for Designing Problems in PBL, 2006)

Keeping these factors in mind when choosing the context and nature of tasks for Bridge 21 workshops can have a significant impact on the motivation and engagement level of girls. The '3C3R' model provides a well-researched framework for the design of PBL tasks or problems which streamlines student ability; instructor's intended objectives and the learning outcomes rather than 'leaving these aspects leaving these aspects entirely to the students' or tutors' interpretations.' (Hung, 2006)



**Figure 16: 3C3R Model for Problem Design in PBL**

“Another PBL implementation issue is that most students who are new to PBL reportedly experience discomfort and frustration at the initial stage of learning” (Hung, 2009). These issues are due to students being used to the traditional instructional methods of rote memorization and assessment

It's important for teachers to be explicitly encouraging and available for support especially for students who are new to the model and make active intervention if they are disinclined to or lack the confidence in becoming active participants of the group activities.



Activity type has also been found to have an impact on overcoming the gender stereotypes in the classroom. Weber and Custer’s research on gender based preferences toward Technology Education Content, Activities and Instructional Methods surveyed students on the preference on a range of activities which were broadly categorized into ‘designing, making, utilizing, and assessing’ types. “At the composite level (the entire activity data set), no significant differences were found between genders. At the subcategory level, however, significant gender differences were detected regarding interest in activities that involved designing and utilizing. Females rated the design activities more interesting than did males, while males preferred utilizing types of activities. (Weber & Custer, 2015)

The figure below summarizes the suggestions for the Project Based Learning pillar and the issues related to the gender gap in STEM and Computing that it targets.

1. Use multidisciplinary problems related to real world STEM application.	Social Context
2. Use the 3C3R model to streamline problem’s intended and perceived objectives.	Hands on Experience
3. Be explicitly encouraging and supportive to girls who are new to PBL.	Confidence Gap
4. Choose a good balance of activities preferred by boys and girls.	Male dominance

#### e. Role of the Mentor

The role of the mentor is instrumental in empowering girls’ belief in their abilities to pursue a career in STEM and Computing in their classrooms. Mentors can foster an environment where help is readily available and hard work and inquisitiveness is valued above knowing the right answer. Creating a rapport so that students aren’t afraid of asking questions lays an important foundation for girls in STEM. (Wiest, 2014)

According to the insights revealed by the Microsoft Study girls are three times more likely to pursue a career in Computer Science if they have support from teachers. (Kesar, 2018).The study also examined the impact of encouragement at home and found that teacher and parent support combined can have the most sizeable outcomes on their academic choice.

Mentors can extend advice to parents about how to support girls at home and provide more exposure to STEM activities, especially if they have observed peripheral performers in the class who have the potential but lack the self-efficacy beliefs.

Helping females develop positive predilection to their capabilities in STEM, strengthening your own beliefs that females and males are equally capable and that these fields are equally appropriate for both genders, and reflecting this belief in your interaction with students is of absolute relevance.

In-class interaction with both boys and girls should be uniform, for example inviting girls as much as boys to give open feedback answers and demonstrations, ensuring that both are active and purposeful contributors to the group work and creating accountability in a well-disposed manner.

Subsequent to the discussion on activities and topics that are either stereotypically associated with boys or girls, mentors should strive to ‘Use gender-fair teaching materials. For example, use a fairly even balance of whole-class tasks that include stereotypical female contexts (e.g., shopping, cooking, art/literature), stereotypically male topics (e.g., sports, politics, economics), and “neutral” topics (e.g., animals, food, music).’ (Wiest, 2014)

The figure below summarizes the suggestions for the Mentor pillar and the issues related to the gender gap in STEM and Computing that it targets.

1. Value hard work and curiosity over knowing the right answer.	Confidence Gap
2. Extend advice to parents (especially fathers!) to provide more exposure to STEM and encourage girls at home.	Providing encouragement at home and school
3. Strengthen your own and girls’ belief in STEM and Computing abilities.	Providing hands on experience.
4. Reflect inclusiveness in classroom and group interactions.	Male dominance
5. Use a good balance of stereotypically male and female topics.	

## 5.2 Project Conclusion

The factors affecting the absence of women in STEM are manifold and operate in a complex fashion. This paper proposes the use of Bridge 21 as a candidate learning model for STEM and Computing studies which accelerates the acquisition of key 21<sup>st</sup> century skills which, when implemented along with the suggestions in the concluding section, has the potential

to positively impact self-efficacy belief in girls and consequently influence their academic choices in favour of STEM and Computing.

‘Girls’ disadvantage is not based on cognitive ability, but in the socialisation and learning processes within which girls are raised and which shape their identity, beliefs, behaviours and choices.’ (UNESCO, 2017) Engaging more girls in STEM and Computing has to be a sustained effort at policy, education, class room, extracurricular and social level that enables girls to recognize their ability and see STEM as a means to solving crucial challenges in society.

### Works Cited

- Higher Education Authority IE. (2017). *Key Facts and Figures*. Retrieved April 2018, from hea.ie: <http://hea.ie/assets/uploads/2018/02/HEA-Key-Facts-And-Figures-2016-17-FINAL.pdf>
- Microsoft Whitepaper. (2017, March). *Why Europe's Girls aren't studying STEM*. Retrieved April 2018, from Microsoft News: [https://news.microsoft.com/uploads/2017/03/ms\\_stem\\_whitepaper.pdf](https://news.microsoft.com/uploads/2017/03/ms_stem_whitepaper.pdf)
- Appianing, J., & Van Eck, R. N. (2015). GENDER DIFFERENCES IN COLLEGE STUDENTS’ PERCEPTIONS OF TECHNOLOGY-RELATED JOBS IN COMPUTER SCIENCE. *International Journal of Gender, Science and Technology* vOL 17, 28-56.
- Binkley, M., Erstad, O., Herman, J., Raizen, S., & Ripley, M. (2012). Defining Twenty First Century Skills. In P. Griffin, & E. Care, *Assessment and Teaching of 21st Century Skills* (pp. 17-66). Dordrecht, Netherlands: Springer.
- Blatchford, P., Kutnick, P., & Galton, M. (2003). Toward a social pedagogy of classroom group work. *International Journal of Educational Research*, 153-172.
- Blickenstaff, J. C. (2005). Women and science careers: leaky pipeline or gender filter? *Gender and Education* , Vol 17 , 369-386.
- Cheema, J. R. (2014). Some General Guidelines for Choosing Missing Data Handlign Methods in Educational Research. *Journal of Modern Applied Statistical Methods* , Volume 13 Issue 2, 53-75.
- Cher, P. L., & Ching, S. C. (2013). Creating a conducive learning environment foreffective integration of ICT: Classroom Management Issues. *Journal of Interactive Learning Research* 14(4), 405-423.
- Chiaburu, D. (2005). The effects of instrumentality on the relationship between goal orientation and leader-member exchange. *The Journal of Social Psychology*, 365-367.
- Citizens Information . (2013, January 22). *Overview of the Irish Education System*. Retrieved March 12, 2018, from Citizens Information: [http://www.citizensinformation.ie/en/education/the\\_irish\\_education\\_system/overview\\_of\\_the\\_irish\\_education\\_system.html](http://www.citizensinformation.ie/en/education/the_irish_education_system/overview_of_the_irish_education_system.html)
- Cooper, R., & Heavenlo, C. (2013). Problem Solving And Creativity and Design :What Influence Do They Have On Girls’ Interest In STEM Subject Areas? *American Journal of Engineering Education*, 27-38.

- Daly, E., Farrell, G., & Grimson, J. (2017). *Fixing the Leaky Pipeline and Retaining Our Talent*. Dublin, Ireland: Engineering and Computing Sciences Committee of the Royal Irish Academy.
- Department of Education - USA. (2016). *STEM 2026 - A vision for innovation in STEM education*.
- Department of Education and Sciences. (2013-14). *Transition Year School Guidelines*. Retrieved March 12, 2018, from Education.ie: [https://www.education.ie/en/Schools-Colleges/Information/Curriculum-and-Syllabus/Transition-Year-ty\\_transition\\_year\\_school\\_guidelines.pdf](https://www.education.ie/en/Schools-Colleges/Information/Curriculum-and-Syllabus/Transition-Year-ty_transition_year_school_guidelines.pdf)
- Department of Education and Skills. (2017). *Action Plan for Education*. Dublin IE.
- Department of Education and Skills. (2018, January 04). *Minister Bruton announces Leaving Certificate Computer Science subject*. Retrieved February 18, 2018, from Education.ie: <https://www.education.ie/en/Press-Events/Press-Releases/2018-press-releases/PR2018-01-04.html>
- Dewey, J. (1933). *How we think: a restatement of the relation of reflective thinking to the educative process*. Boston: MA: D. C. Heath and Company.
- Dubois Shaik, F., & Fusulier, B. (2015). *Academic Careers and Gender Inequality: Leaky Pipeline and Imterrelated Phenomena in Seven European Countries*. GARCIA Working Papers 5 (University of Trento).
- Fisher, A., & Jane, M. (2002). Unlocking the clubhouse: the Carnegie Mellon experience. *ACM SIGCSE Bulletin - Women and Computing Volume 34 Issue 2*, 79-83.
- Glinski, A. M., Weiss, E., Shetty, A., & Gaynair, G. (2013). *Preparing Girls and Women for 21st Century Success: Intel Teach Findings*. International Center for Research on Women.
- Hamdan, N., Mc Knight, P., Mc Knight, K., & Arfstrom, K. M. (2013). A review of Flipped Learning. *Flipped Learnign Network*.
- Higher Education Authority. (2017). *New Entrants by Age and Gender* . Retrieved April 2018, from HEA.ie: <http://hea.ie/statistics-archive/>
- Higher Education Authority. (2017). *New Entrants by Education and Gender*. Retrieved April 2018, from Hea.ie: <http://hea.ie/statistics-archive/>
- Higher Education Authority. (2017). *New Entrants by Institution, Gender and Field of Study*. Retrieved April 2018, from hea.ie: <http://hea.ie/statistics-archive/>
- Howe, C. (1997). Gender and Classroom Interaction. *The Scottish Council for Research in Education*, 9-31.
- Howe, C. (1997). Gender and Classroom Interaction. *The Scottish Council for Research nd Education*, 9-30.
- Humphreys, J. (2014, September 18). *Mixing age groups in class affects girls more than boys*. Retrieved April 2018, from IrishTimes.ie: <https://www.irishtimes.com/news/education/mixing-age-groups-in-class-affects-girls-more-than-boys-1.1932625>
- Hung, W. (2006). The 3C3R Model: A Conceptual Framework for Designing Problems in PBL. *Interdisciplinary Journal of Problem-Based Learning V1 Issue 1*, 55-77.
- Hung, W. (2009). The 9-step problem design process for problem-based learning: Application of the 3C3R model. *Educational Research Review Vol4 Issue 2* , 118-141.
- Iclaves SL for the European Commision. (2013). *Women Active in the ICT Sector*. Madrid ES.

- Kay, K., & Shipman, C. (2014, May). *The Confidence Gap*. Retrieved March 20, 2018, from The Atlantic: <https://www.theatlantic.com/magazine/archive/2014/05/the-confidence-gap/359815/>
- Kennedy, J. (2017, February 13). *The Gender Gap in College Courses*. Retrieved April 2018, from Trinity News: <http://trinitynews.ie/the-gender-gap-in-college-courses/>
- Kesar, D. S. (2018). *Closing the STEM gap : Why STEM Classes and Careers still lack girls and what we can do about it* . Microsoft .
- La Force, M., Noble , E., & Blackwell , C. (2017). Problem-Based Learning (PBL) and Student Interest in STEM Careers : The Roles of Motivation and Ability Beliefs. *Education Sciences Basel Vol7 Iss 4*, 92-114.
- Lawlor, J., Conneely, C., Oldham, E., Marshall, K., & Tagney, B. (2018). Bridge21: teamwork, technology and learning. A pragmatic model for effective twenty first century team based learning. *Technology, Pedagogy and Education*, 1.
- Lawlor, J., Marshall, K., & Tagney, B. (2016). Exploring the potential to foster intrinsic student motivation through a team based, technology mediated learning model. *Technology, Pedagogy and Education*, 187-206.
- Lee, M. (1993). Gender, Group Composition, and Peer Interaction in Computer Based Cooperative Learning. *J. EDUCATIONAL COMPUTING RESEARCH*, Vol. 9(4), 549-577.
- Manly, C. A., & Swells, R. S. (2014). Reporting the Use of Multiple Imputation for Missing Data in Higher Education Research. *Research in Higher Education Volume 56 Issue 4*, 397-409.
- Margolis, J., & Fisher, A. (2003). *Unlocking the Clubhouse: Women in Computing*. Cambridge MA: The MIT Press.
- Martin W. Moakler Jr., M. M. (2014, June). College Major Choice in STEM: Revisiting Confidence and Demographic Factors. *The Career Development Quarterly Volume 62*, pp. 128-142.
- Michaelsen, L., & Sweet, M. (2008). Creating effective team assignments. *Team-based learning for health professions education: A guide to using small groups for improving*, 35-60.
- Mitra, S., & Quiroga, M. (2012). Children and the Internet. A preliminary study in Uruguay. *International Journal of Humanities and Social Sciences*, 11-17.
- Murthy, S. (2015, June 17). *Measuring Gender Diversity with Data from LinkedIn*. Retrieved February 08, 2018, from Official Linked In Blog: <https://blog.linkedin.com/2015/06/17/measuring-gender-diversity-with-data-from-linkedin?sf10026881=1>
- O Sullivan, K., Kuster, M., Smith, R., Byrne, J., Keane, L., Tagney, B., & Hannon, C. (2016). *Trinity Access 21 :Year 1 Report*. Dublin, Ireland: Trinity Access 21.
- OECD. (2018). Empowering women in the digital age : Where do we stand? *62nd session of the UN Commision on the Status of Women* (pp. 5-10). New York City US: OECD.
- Ossola, A. (2014, November). *Black Girls stand a better chance in STEM*. Retrieved March 2018, from The Atlantic : <https://www.theatlantic.com/education/archive/2014/11/black-girls-stand-a-better-chance-in-stem/383094/>
- Park, H., & et al. (2011). *Causal Effects of Single-Sex Schools on Students' STEM Outcomes by Gender and Prenatal SES*. Retrieved March 2018, from Princeton.edu: <http://paa2011.princeton.edu/papers/111625>

- Parmar, B. (2013, October 13). *Co-Educational Schools are bad for girls* . Retrieved March 2018, from The Guardian: <https://www.theguardian.com/women-in-leadership/2013/oct/30/co-educational-schools-bad-for-girls>
- Prinsen , F. R., Volman, M., & Terwel, J. (2006). Gender-related differences in computer-mediated communication and computer-supported collaborative learning. *Journal of Computer Assisted Learning*, 393-409. Retrieved from Wiley Online Library.
- Savery, J. R., & Duffy, T. M. (1995). *Problem Based Learning : An Instructional Model and Its Constructivist Framework*. New Jersey: Education Technology.
- Science Foundation Ireland. (2016). *Gender Strategy 2016-2020*. Dublin IE: SFI.
- Sciences, D. o. (2013-14). *Transition Year School Guidelines*. Retrieved March 12, 2018, from Education.ie: [https://www.education.ie/en/Schools-Colleges/Information/Curriculum-and-Syllabus/Transition-Year-/ty\\_transition\\_year\\_school\\_guidelines.pdf](https://www.education.ie/en/Schools-Colleges/Information/Curriculum-and-Syllabus/Transition-Year-/ty_transition_year_school_guidelines.pdf)
- Swain, S. L., & Harvey, D. M. (2002). Single-sex computer classes: An effective alternative. *Tech Trends Volume 46 Issue 6*, 17-20.
- The Alliance of Girls' Schools. (2013). Engaging Girls in STEM. *2013 Student Leadership Conference* (pp. 7-9). Hobart AUS: The Alliance of Girls' Schools Australasia.
- Thomas, J. W. (2000). *A Review of Research on Project Based Learning*. Retrieved 5 3, 2018, from BobPearlMan.org: Retrieved from [http://www.bobpearlman.org/BestPractices/PBL\\_Research.pdf](http://www.bobpearlman.org/BestPractices/PBL_Research.pdf)
- UNESCO. (2017). *Cracking the Code : Girls' and women's education in science, technology, engineering and mathematics(STEM)*. Paris: UNESCO.
- Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Cambridge MA: Harvard University Press .
- Weber, K., & Custer, R. (2015). Gender-based Preferences toward Technology Education Content, Activities and Instructional Methods. *Journal of Technology Education Vol 16 No.2*, 55-71.
- Wiest, L. R. (2014, July). *Strategies for Educators to Support Females in STEM*. Retrieved April 2018, from unr.edu: <http://www.unr.edu/girls-mathcamp/>
- Wiest, L. R., & Johnson, S. (2005). *Providing Female Role Models in Mathematics and Science*. Retrieved April 2018, from Eric.ed.gov: <https://files.eric.ed.gov/fulltext/EJ793998.pdf>
- Zeldin, A. M., Britner, S. L., & Pajares, F. (2008). A Comparative Study of the Self-Efficacy Beliefs of Successful Men and Women in Mathematics, Science, and Technology Careers. *Journal of Research in Science Teaching, v45*, 1036-1058.