Executive Summary

Introduction

It is estimated that by the end of 2016 there will be 1.5 million computer science related jobs available worldwide. Furthermore, by 2018, 75% of all jobs will require significant college preparation. This report provides an overview of the year one findings from the three-year longitudinal project Trinity Access 21 (TA21) which aims to address this Science, Technology, Engineering, Math and Computer Science (STEM/CS) college gap. The project promotes change in the second level education system through the development of the 21st century teaching and learning environment, STEM/CS skills in the classroom and strong, ‘college-going’ cultures in communities where progression to higher education is low.

Context

Reading, writing and arithmetic have generally been considered the main stays of education. But as our society and the global economy continue to drive toward the digital, it is clear that we must now add new core topics to the national curriculum. These include Science, Technology, Engineering, Math and Computer Science (STEM/CS). In 2009, the United States Department of Labor listed the ten most wanted employees. Eight of those employees were ones with degrees in the STEM/CS fields: including accounting, computer science, electrical engineering, mechanical engineering, information sciences and systems, computer engineering and civil engineering. According to the Irish Higher Education Authority, STEM occupations are growing at 17%, while others are growing at 9.8%. Similarly, the technology industry is currently one of the fastest growing, providing new opportunities to people with skills in technology development. In Ireland there are very strong employment opportunities in Computer Science and ICT, with graduates in those areas reporting high levels of employment and pay.

In a society which is being driven by technological advancement it is essential that students are leaving school college-ready and equipped with the skills to be productive in the job market once they graduate. The challenges facing the current education system in preparing these students includes integrating STEM/CS subjects into an already jam-packed schedule, and fuelling students interest during primary and secondary school. Furthermore, there is a clear need to help teachers more efficiently and productively develop their own skills.

The TA21 project was developed to help schools meet the developing needs of modern society; it is a creative collaboration involving the Trinity Access Programmes, Bridge21, the School of Education and the School of Computer Science & Statistics in Trinity College Dublin, supported over the 2014-17 period by Google.

TA21 addresses the issues facing the modern school and student by providing teachers with opportunities to participate in 21st century STEM/CS professional development and by developing college-going cultures in schools situated in communities where progression to higher careers and college is historically low.

Goals of TA21

The TA21 project has a number of key goals, they are:

- To increase the STEM/CS capabilities of teachers across the Irish second level education system
- To raise STEM/CS awareness across the Irish second level education
- To support schools to develop and promote 21st Century Teaching & Learning environments
- To support educational attainment and post-secondary progression in geographical areas where attendance at third level is historically low
- Build an evidence base that informs policy and structural change (See Figure

**Figure 1: Trinity Access 21 Theory of Change**

**TA21- what the project looks like**

The project partnered with eleven schools across the greater Dublin region for year 1; this partnership required each school to build a team of ten teachers who would participate in fully subsidised opportunities in 21st Century STEM/CS continuing professional development CPD and implement a College for Every Student (CFES) intervention with all 2nd year students. The CPD was offered in two forms. The first was an accredited level 9 Post Graduate Certificate (PG Cert) in 21st Century Teaching & Learning in Trinity College Dublin, leading to Diploma or Masters level study for some participants. The second offering was STEM/CS weekend workshops, which included training in Raspberry Pi, Scratch 1 and 2 and Python. The second offering was not limited to the eleven schools and was made available to teachers across Ireland. A three-year longitudinal, mixed-method, research project with over 200 teachers and 1500 students was also undertaken.

“I’m going to teach them Romeo and Juliet with Scratch ...which will be great!” (PG Cert Teacher 1)
Key Findings

Results of data analysed revealed that:

• 485 teachers participated in STEM/CS workshops in year one

• 81 teachers, representing 27 schools, completed the PG Cert in 2014/15. Of these, 28 teachers have progressed to Masters

• 1100 14-year old students participated in TA21-CFES: which included over 3000 college-focused mentoring sessions, 800 students visiting TCD, and 20 student led service projects

• Participation in the TA21 STEM/CS CPD offerings had a positive effect on teachers STEM/CS skills which resulted in over 4000 students having at least one STEM/CS classroom experience during year one of the three-year project.

• Participation in the PG Cert increased the level of 21st century teaching practices in the classroom, with students being more likely to lead projects, collaborate, and use technology creatively in a self directed manner.

• Being a part of the TA21-CFES affected students college and career plans; now more (12% increase) students intend to progress onto college, and more (22% increase) students plan to pursue careers that require a college education as a direct result of the TA21 project.

Barriers

The report finds that there are structures in the education system that act as significant barriers to more widespread implementation of STEM/CS learning. These include:

• Class times: teachers state they are too short for technology-mediated learning to become embedded in the classroom

• Teaching to the test: teachers do not have the authority or time to adapt the junior and senior cycle curriculum to incorporate STEM/CS content

• Resources: schools do not have the technology available to bring STEM/CS into the classroom

Recommendations

These barriers require further investigation and remedial action if STEM/CS is to become integrated into the Irish classroom.

Recommendations which may support this change include:

• Extending class times: it is recommended that class times be extended from 40 minutes to at least one hour. This will allow teachers embed collaborative, team-based, technology-mediated activities in the classroom.

• Include computer science as a standalone subject in the curriculum starting in the junior cycle: the skills taught in classes like computer programming develop students in ways that help them over the long term. They learn how to check their work for details, how to apply logic and how to persist at a task. They also learn how to ask a good question, often in written form and how to collaborate.

• Invest effectivley in ICT in schools: move away from the ‘computer room’ approach, make ICT part of each and every classroom.

• Increase the oppurtunities for teachers to participate in accredited STEM/CS CPD: provide a structure where teachers are given time to develop these skills in a supportive structure.

TA21 Future Vision

The TA21 project is the beginning of a movement in Irish schools that will continue to grow. Based on year one observations, TA21 has endeavoured to develop the project in the following ways:

1. Scale teacher participation in the PG Cert and STEM/CS workshops and build partnerships with more schools, sponsors and post-secondary institutions nationwide;
2. Develop a structure within the eleven project schools which embeds STEM/CS into the existing curriculum: this includes lesson plans in subject areas deemed ‘less suitable’ to STEM/CS content;
3. Create a digital toolkit, which contains examples of best practice, for teachers to use as a resource: this includes lesson plans, student resources and innovative ideas;
4. Develop a national School of Distinction award: this will reward schools who demonstrate excellence or innovation in several areas. These include whole school implementation of STEM/CS, college and career awareness, mentoring, special education, parental involvement;
5. Support schools to develop stand alone STEM/CS courses that can run during the school day: this will speak directly to the junior cycle short course in coding;
6. Continue to build an evidence base that speaks directly to national policy and structures.
Context

Reading, writing and arithmetic have generally been considered the main stays of education. But as our society and the global economy continue to drive toward the digital, it is clear that we must now add new core topics to the national curriculum. These include Science, Technology, Engineering, Math and Computer Science (STEM/CS). In 2009, the United States Department of Labor listed the ten most wanted employees. Eight of those employees were ones with degrees in the STEM and CS fields: accounting, computer science, electrical engineering, mechanical engineering, information sciences and systems, computer engineering, civil engineering. According to the Irish Higher Education Authority, STEM occupations are growing at 17%, while others are growing at 9.8%. Similarly, the technology industry is currently one of the fastest growing, providing new opportunities to people with skills in technology development. In Ireland there are very strong employment opportunities in Computer Science and ICT, with graduates in those areas reporting high levels of employment and pay.

In a society which is being driven by technological advancement is seen all that students are leaving school not only college-ready but equipped with the skills to be productive in the job market once the y graduate. The challenges facing the current education system in preparing these students is complex; they include integrating STEM/CS subjects into an already jam-packed schedule, and driving student interest during primary and secondary school. Furthermore, there is a clear need to help teachers more efficiently and productively develop their own skills.

There is growing recognition of the need for change in pedagogical practices in order for teachers to provide students with the opportunities to develop the skills needed for the 21st century. For example, Kozma and Anderson (2002), through a large-scale study spanning 28 countries, identified pedagogical practices that move away from traditional talk and chalk methods; that include using ICT in a collaborative learning environment to solve real-world problems. They characterized innovate pedagogical practices as those that go beyond passive learning, where ICT is being used to support the solving of authentic real-world problems, facilitating collaborative learning and the self-management of learning goals. These observations have led several countries to review their curriculum orientation and the related professional development offerings for new and existing teachers. In the Irish context, reform of Post-primary education has been underpinned by overlaying curriculum content with selected Key Skills (National Council for Curriculum and Assessment, 2009).

While continuous professional development (CPD) has long been touted as the means by which teachers can adapt to new innovations in learning, in practice CPD has had mixed success: Harford (2010, p.355) describes this: “Teachers’ experience of continuous professional development is fragmented and open ad hoc and CPD itself is narrowly defined, lacking in theoretical basis, and rolled out in stops and starts rather than in any coherent or sustainable way”.

The second level system, and the process of admission to third level, has come under considerable criticism in recent years regarding an excessive focus on teaching to the test and the ‘backwash’ effect this is having on school leavers. Ireland, like many other countries, does not have enough students taking STEM courses and even though Ireland is a hub for high tech companies the country suffers shortages of graduates in the area of computing.

In 2012, the then Minister of Education launched an ambiguous programme to reform the Junior Cycle component of the secondary school system. The importance of the high-stakes, statewide, examination at the end of the Junior Cycle was to be reduced with schools being afforded much more autonomy in what they taught, how they taught it and how they assessed what was taught. The reforms envisaged placing considerable emphasis on the development of key skills and competencies along with covering a scaled back traditional curriculum. The subject of computing, or coding, as a formal subject in the secondary school curriculum is one which has come up a number of times in the past few decades. At present, a syllabus for a course on “digital media literacy” at the Junior Cycle has been published, as has one on computer coding. It is within this context that the Trinity Access 21 project has been developed, which is explained in more detail in the following second.
Trinity Access 21 Project

In 2014, the Trinity Access 21 (TA21) project was launched to address some of the issues described in the previous section. TA21 is a three-year project (2014-17) which aims to effect change in the Irish education system through: (1) Preparing teachers to teach Computer Science and related topics through a collaborative, co-teaching model of learning and (2) Increasing the number of students from DEIS schools pursuing STEM/CS-focused college courses and careers. In order to address:

- The promotion of STEM and Computing capability (especially with female students)
- The creation of schools which promote 21st century teaching and learning
- Educational attainment and post-secondary progression in some geographical areas

- it is necessary to work across the education sector at a number of levels as depicted in Figure 1.

Teaching and Learning in the Classroom

1. The Irish second level education system aims to promote elements of 21st century teaching and learning and it is acknowledged that teachers require support to implement these pedagogical changes. 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.

2. For students to work collaboratively they need to receive training in collaborative methodologies. Since 2008, over 10,000 students have participated in workshops introducing them to the Bridge21 model and this work is ongoing through workshops offered in Trinity College Dublin (TCD) and in partner schools.

3. To facilitate teachers adopting a 21st century approach to teaching and learning a suite of template learning activities, based upon the Bridge21 model, has been created across a range of curriculum areas ranging from computing, through maths to history.

4. To assist teachers in change management, TCD is offering a Postgraduate Certificate in 21st Century Teaching and Learning (PG Cert) addressing issues around social inclusion and adopting 21st century teaching & learning practices. By the end of the academic year 2015/16, 180 teachers will have completed the PG Cert.

5. A particular focus of the PG Cert is on STEM/CS and, to this end, topics related to computer coding are offered as part of the PG Cert. This will provide teachers with the requisite skills to teach STEM/CS, and to integrate STEM/CS practices into the current curriculum. Teaching STEM/CS is becoming increasingly important; by 2020 the modern workforce will require employees to be capable in all aspects of computing and coding. Coding workshops are also available to teachers on a non-accredited, ‘a la carte’ basis.

Academic Capital Formation

6. The College for Every Student core practices (Mentoring, Leadership Through Service and College Awareness) are being implemented in a core network of 11 schools over a three-year period and the research data being gathered indicate that the practices are effective in developing academic capital. This is manifesting in improved attitudes to progressing to third level. The model is drawn from an educational non-profit in the US, College for Every Student (CFES), and it has been adapted and piloted within the Irish context.

Evidence and Policy Formation

7. TA21 includes a substantial longitudinal research component, which is assessing the impact of all the aspects of the initiative on both students and teachers. A number of papers have already been published.

8. Based on the experiences of the project and the evidence accumulated to date, TA21 seeks to contribute to, and inform, the national debate on social inclusion, access to Third level, 21 century teaching & learning and STEM/CS

TA21 aims to embody the ideas which it is promoting. It is a highly innovative and creative collaboration involving the Trinity Access Programmes, Bridge21, the School of Education and the School of Computer Science and Statistics in Trinity College Dublin. The second level schools are partners in the process as co-researchers and the international collaboration with the CFES organisation and their network of schools is significant. The project does not seek to address the various issues in isolation but takes the view that a coherent interrelated suite of initiatives is required to address the complex issues involved.
Impact and Evaluation

In order to develop an evidence base that could be used to effect change at a national policy level, a rigorous quantitative and qualitative research protocol was put in place to evaluate the impact of the overall TA21 intervention. This protocol was developed to align directly to the broad aims of the overall project. It was separated into three areas; the first looked at the specific STEM/CS outcomes, the second examined the 21st century teaching practices and the third examined student aspirations. While these are being reported as distinct entities the three-year longitudinal study takes an overarching examination of educational change in the 11 partnered schools. The following section describes the research methods employed for the three sections.

STEM/CS
The STEM/CS teacher research focused on teachers participating in the STEM/CS workshops; teachers completed surveys (n=400) and interviews that examined their experience of the workshops, and their confidence to implement the workshop content in their own classrooms. A group of teachers (n=50) who had not participated in the STEM/CS workshops, completed the surveys, and acted as a comparative control group. Seventy four teachers completed a survey administered at the end of Year 1 to establish the impact that participation had on teachers’ classroom practices and further developments since participation.

PG Cert
This research focused on the teachers completing the PG Cert; 54 teachers on the course completed surveys which examined changes in attitudes towards technology in teaching and their current teaching practices over the year. For comparison purposes a sample of teachers from the same schools as those who were completing the PG Cert participated in the research and acted as a comparative control group; 34 teachers completed the same survey as the PG Cert teachers.

TA21-CFES Students
The student research focused on 11 TA21-CFES schools. In total 800 students completed surveys which examined changes in college and career knowledge and aspirations before and after Year 1. For comparison purposes, students from two DEIS (termed ‘TAP’ from herein) schools who were not participating in the project participated in the research; 147 students from these schools completed the same surveys as the TA21-CFES students. Students from two schools with high (termed ‘High’ from herein) progression rates to post-secondary education also participated in the research; 131 students from these schools completed the same surveys as the TA21-CFES students. The survey examined student knowledge of higher and further education and their college and career aspirations.

“Where we have funding for interventions, even if it is for the best possible motive, even if the people who participate think they are effective, unless we have the rigorous experiments in place to test these out we cannot be sure that money is being spent to the greatest advantage. . . . You could have a series of interventions, with some of them being very effective, others being less effective, and some being harmful. Unless you have a fair test and actually look at what would have happened to the participants had they not received the intervention, you don’t actually know.” (Evaluating Access, Sutton Trust 2015)
Research Findings: STEM/CS

- 50% teachers in STEM/CS workshops teach non-STEM subjects.
- 4800 students in TA21 schools participated in at least one STEM/CS classroom activity in Year 1.
- 63% teachers who participated in workshops introduced new STEM/CS content in class.
- 246 teachers took part in more than 3 STEM/CS workshops.
STEM/CS Description

The TA21 project team developed a series of stand-alone workshops for teachers who wanted to develop their Computing and ICT capabilities. These vary in STEM/CS focus and content and are described in Table 1. The workshops can also be taken within the PG Cert.

Participation

The STEM/CS workshops reached over 400 teachers, from 16 counties nationwide in the first year of the project, with 50% completing 3 workshops and 70% completing 2 workshops. Teachers from across all subject disciplines participated, although 50% of participants had a STEM background. Many of those who completed the workshops progressed onto future STEM/CS CPD offerings, suggesting that these workshops are a good starting point for teachers intending to develop their CS competencies.

Confidence to teach programming

Participation in the TA21 STEM/CS workshops has given teachers the confidence and ability to implement changes to their teaching practice and supported them to teach CS. For example, teachers who have participated in Scratch 1 and 2 have significantly higher confidence to plan and implement Scratch animation learning activities, and to teach computer programming through Scratch, in comparison to teachers who had no training. This is seen in reports from teacher Helen O’Kelly in case study 1; she found that participation in the STEM/CS activities increased her confidence to teach programming and she was also more motivated to look for further training. Teachers also reported that participating in both Scratch 1 and 2 was more influential than Scratch 1 on its own. Teachers’ confidence to use the content of the STEM/CS workshops was significantly higher for all offerings (Python, Raspberry Pi) than teachers who did not participate in any training (Figure 2).

Barriers

While teachers who had completed the workshops were more knowledgeable and confident, a third said they were unable to apply their learning in the classroom. The following section describes the key barriers that teachers faced in their classroom:

1. Time:

   Teachers said the timetable, which typically provides just 40 minutes of time per single class, limited the capacity for them to implement their newfound STEM/CS skills. One teacher stated that there was “just no time” to use her new skills and she was frustrated by the lack of support in the school structure to support these changes. Teachers have tackled this by forming afterschool-clubs or developing classes within school time that are not restricted by timetabling. Other teachers have taken students to outside STEM/CS activities to give them some STEM/CS experience.

   Some schools have taken a more supportive, systemic approach, and have extended class times from 40 minutes to one hour. This has allowed teachers to embed their learning in the classroom. Case study 3 is a prime example of this. The school adopted longer class times which has resulted in increased application of the STEM/CS content. The principal of this school highlights the changing language across the school; she states “The talk in the hallways and the classrooms has changed.... 75% of teachers say they are using more active teaching methodologies”. When there is adequate time given, there is wider implementation of STEM/CS across the school, and more teachers are pursuing further CS development as a result.

2. Teaching to the test:

   Teachers said that implementation of STEM/CS content was restricted to cohorts not in ‘exam’ years, as there is a large curriculum to cover for state examinations. One teacher who attended the PG Cert stated that there was “no way” he could use the content STEM/CS in an exam year as it would mean missing some of the core curriculum. This was seen across the schools and teachers. The majority of teachers applied the content in non-examination years.

   Teachers said they needed more time to plan how best to incorporate STEM/CS into the curriculum. In the case of Mathematics and Business, teachers were less restricted and saw the content as relevant whereas English, History and Language teachers said planning time was a significant barrier. In cases where planning hours were allocated to teachers to incorporate STEM/CS content there was evidence of cross-curricular application. For example, one teacher reported building a website with students, but stated this would not have happened without planning time to consider how to match STEM/CS with the curriculum.

   “I will attempt basic scratch exercises with my transition year as they have no exam content to learn. However, given the 40 minute class limit, I will try to work on weekly tasks over 3 lessons” (PG Cert Teacher 3)

   “Realistically I cannot see me using it in my subject as we do not have enough class time.” (STEM/CS Teacher 2)

![Figure 2: Teacher confidence in use of programming](image)
<table>
<thead>
<tr>
<th>Digital Media Literacy</th>
<th>Computational Thinking</th>
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<tr>
<td>This workshop immerses participants in the experiential, activity-based Bridge21 learning model, developing teachers’ ability to use digital technology, communication tools, and the internet creatively and innovatively. It develops technical skills (audio recording and video and graphic media production) and explores popular topics (online safety, information evaluation and copyright and intellectual property).</td>
<td>At the heart of all computer programming is the ability to “think like a computer”. Through activities, teachers explore how to develop students’ 21st century thinking skills, including problem solving, data visualisation, modelling real world problems and developing algorithms, almost all without using computers.</td>
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<tr>
<td>Scratch 1 and 2</td>
<td>Python</td>
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<td>Scratch is a popular visual programming language developed by MIT. Using a simple drag-and-drop, block-based interface to develop animations and games, these workshops are delivered through the Bridge21 model, all while developing an understanding of many computational concepts such as initialisation, variables, loops and events.</td>
<td>With its simple syntax, powerful features and flexible applications, python-programming language is widely used as an introduction to coding. Delivered using the Bridge21 model, this workshop focuses on an introduction to the Python language by developing mathematical algorithms to solve problems.</td>
</tr>
<tr>
<td>Raspberry Pi</td>
<td>Contextual Mathematics</td>
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<td>The Raspberry Pi is a small, programmable computer with a set of interfaces allowing it to control other devices. Delivered through the Bridge21 model, the workshop explores computers systems and how we can use them to interact with the world around us.</td>
<td>Delivered through the Bridge21 model and grounded in a view of mathematics as a problem-solving activity in which students construct knowledge by solving real world problems, this workshop introduces technology-mediated, maths learning activities including ‘Probability and Plinko’, ‘The Pond Filling Activity‘ and ‘The Human Catapult’.</td>
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3. Resources

In schools where resources were limited teachers were less likely to apply their learning. Schools on the TA21 project, who were deemed disadvantaged from the start, had less access to resources. One teacher stated “We have one computer room in our school, with 25 computers for 500 students, and most of them are broken”. Teachers in these schools were more likely to bring the students to activities outside of the school than embed the learning in the classroom. Conversely, schools where there was funding for technology were more likely to embed the STEM/CS content in the classroom. Over 60% of the schools that participated in the TA21 project reported having little access to the technology needed to make a real impact in their school. Most had one or two computer rooms that were shared by several classes. There were cases where schools had no access to WiFi or the Internet.

“I am so glad I have completed this now, it is done, it is there forever now and the students can keep adding to it each year”. (PG Cert Teacher 4)

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Case Study 1: With motivated teachers the sky is the limit

Helen O’Kelly is an IT teacher, IT coordinator and a librarian in Stratford College. Before participating in the STEM/CS workshops she understood the value of IT in the classroom but lacked the skills to implement advanced programming. Since participating, Helen has gone on to complete the PG Cert and has created meaningful STEM and CS experiences for all students in her school. Here is her story.

In June 2015, a colleague forwarded me an email about Bridge21 and I saw this incredible list of workshops including Information Literacy! I attended a two-day Python/Raspberry Pi workshop that same month where I heard about the Postgraduate Certificate in 21st Century Teaching and Learning. Knowing that I was going to teach 1st – TY students the ECDL ICT and Computing Curricula modules from the following September, I knew that I had to do this course.

I applied to the Postgraduate Certificate to get more technical training in Scratch, Python and Raspberry Pi. I also wanted to do the course to get pedagogical training. I got more than that. I met other school librarians and teachers who gave me great insights into teaching. I was exposed to a project-driven and hands-on teaching model in our workshops, just like we were to teach our students. I found out about computational thinking skills and activities and an activity model to plan our classes. I learned about ‘doing hard fun’, the more able-other and the importance of reflection.

The Postgraduate Certificate in 21st Century Teaching and Learning changed everything for me. It gave me the pedagogical framework, backed up by academic evidence, to teach in a way that my students would not only learn to understand, but also learn 21st century skills such as critical thinking, collaboration and creativity. It gave me a real understanding of the power of a Raspberry Pi and GPIO pins with breadboards. Completely from the ground up, I set up four in the school computer lab, with WiFi and sound – no kits!

I now feel confident to teach Python to TYs. I learned about educational theories such as social and cognitive constructivism and how to apply this knowledge to class plans. I learned the importance of having a rationale for class activities and marking schemes and reflecting on classes by asking ‘so what?’ and ‘what now?’ I learned about differentiation and I learned that I can be honest with students and say that I don’t know. I learned that I must keep learning too. From a student’s perspective, a consistent routine is followed.

Every IT class, from 1st Year to TY, includes a computational thinking exercise as a warm-up. The students love it. Students work in groups, in pairs, or singly depending on the exercises. They’ve written their first algorithms, they work out puzzles, they compute. No computers are involved.

As the 2nd and 3rd Years have one 40-minute IT class a week, we then concentrate on working through two ECDL ICT online modules. The 1st Years have a double class of 80 minutes. The first class is similar to the 2nd and 3rd Years, but the second class gives us time for projects. ‘CoderQuilt 1.0’ was created through knitting, hand-knitting, crochet and pom-poms – similarities between craft patterns and coding were examined. Raspberry Pi punnets were made. Scratch projects are currently being programmed and group research projects on key technological figures are being written. TYs with four 40-minute classes designed and produced a 32-page digital and print 1916 magazine. They wired breadboards and wrote Scratch GPIO code to turn on/off a LED on the breadboard. They learned to code in Python. They competed in a SciFest competition with their Scratch projects.

While doing this course pushed me technically, it also gave me the vision for what I want to do with my students and in my classes. The vision is to practice computational thinking and complete 6 of the 7 online ICT modules by the end of 3rd Year, thereby freeing up more time in TY to work at a more technical level on the CC modules. Introducing coding to 1st Years is critical and taking part in national coding/computational competitions provides motivational targets. Getting students, particularly the girls, to believe that they can do these types of skills is intrinsic to this vision. This vision has given focus to our lunchtime CoderDojo club, as students can practice and create technical artefacts that they decide to do. This paradigm shift in teaching and learning ECDL is a wonder to all students. More and more, students, of their own volition, tell me proudly what they’ve discovered technically by themselves.
485 teachers participated in STEM/CS CPD workshops in 2014/2015.

81 teachers completed the PG Cert in Year 1.

4800 students in TA21 schools participated in at least one STEM/CS classroom activity in Year 1.

28 teachers from TA21 schools progressed to Masters.

243 STEM/CS assignments completed in Year 1.

64 teachers from TA21 schools completed the PG Cert in Year 1.

Research Findings:
Postgraduate Certificate in 21st Century Teaching and Learning
The Postgraduate Certificate in 21st Century Teaching and Learning

The Postgraduate Certificate in 21st Century Teaching and Learning was developed at Trinity College Dublin in 2013/14. It aims to provide teachers with the knowledge and skills to incorporate 21st century teaching and learning practices and to provide their students with opportunities to develop the Key Skills deemed essential to successfully navigate modern society. They include, but are not limited to: information processing, critical and creative thinking, working with others, communicating and being personally effective (National Council for Curriculum and Assessment, 2009).

The Bridge21 model (Figure 3) of team-based, technology-mediated learning was employed as a pragmatic model for 21st century teaching and learning that informed the pedagogy of the PG Cert. The PG Cert is a Level 9 course on the National Framework of Qualifications, with entry requirements for the course including registration with the Irish Teaching Council, a minimum of one year’s teaching experience and possession of qualifications and competencies recognized at Level 8 of the National Framework of Qualifications (for example, a higher diploma or an honours degree). It is a part-time, 12-month course consisting of 6 modules, each worth 5 ECTS (European Credit Transfer and Accumulation System) credits.

A range of STEM and Computer Science modules including Digital Media Literacy, Python and STEM Pedagogy are part of the Postgraduate Certificate with teachers being supported to develop their own 21st century skills in the classroom.

In order to support the TA21 Theory of Change, there is also a range of modules that frame the implementation of change and explore the present educational policy landscape; these are: The Teacher as Co-Researcher, Inclusive Education (related to equality, diversity and (dis) advantage in educational settings) and Leadership and Change Management in Education. Teachers were supported to implement change they had learned about within the PG Cert as each module was assessed by means of a practice-based assignment.

PG Cert Teacher Research Findings

The PG Cert has provided teachers with a structured framework through which 21st century skills are being developed. Following one year of participation, teachers have shown significant improvements in their confidence and ability to implement 21st century teaching and learning techniques in the classroom, in comparison to teachers who did not avail of such CPD. They have also developed more autonomy in their teaching practice and teachers who participate are more likely to start-up coding clubs, to look for further CPD opportunities and to take a leading role in initiatives related to 21st century teaching and learning.

All teachers who completed the research demonstrated a greater use of technology-mediated learning in their classroom. However, only the teachers who participated in the PG Cert showed actual improvements in confidence to use technology in teaching, improvements in their technology-related beliefs and developments in their 21st century teaching practices over the year.

“...was great and really helping them talk to each other and come up with ideas, it really was fantastic” (PG Cert Teacher 5)
Confidence and value
Teachers who took part in the PG Cert were more confident, at the end of the year, in using technology in the classroom and ascribed a greater value to the role of technology in their teaching environment. Teachers who participated in the PG Cert were also more confident in their use of computers overall (Figure 4).

Teachers also demonstrated a significant change in their sense of control over the way they teach, what they teach and the way they manage their classroom. This impacted on their subject knowledge, teaching and learning methods and classroom management (Figure 5). The research demonstrated that teachers were using more 21st century teaching practices following the PG Cert. They were more comfortable with fostering an environment where students could be creative and innovative with a variety of media and technology, where they could communicate differently while using this media and technology and where students could be self-directed (Figure 6). The benefit was that students were more exposed to this type of learning environment, which resulted in these practices being more normalised for the students.

The increased emphasis on teamwork suggests that participation in the PG Cert exposed teachers to a multi-faceted pedagogical model that heightened their awareness of aspects of the model that encouraged students to work in teams and also impact the value they ascribed to team-based learning. As a consequence of this, teachers explained they experienced a more positive teacher-student relationship and classroom environment where discipline and classroom management were less of an issue for many teachers, with a more trust-based teacher-student relationship emerging.
Classroom practices

The research demonstrated that teachers were using more 21st century teaching practices following the PG Cert. They were more comfortable with fostering an environment where students could be creative and innovative with a variety of media and technology, where they could communicate differently while using this media and technology and where students could be self-directed (Figure 6). The benefit was that students were more exposed to this type of learning environment, which resulted in these practices being more normalised for the students.

The increased emphasis on teamwork suggests that participation in the PG Cert exposed teachers to a multi-faceted pedagogical model that heightened their awareness of aspects of the model that encouraged students to work in teams and also impact the value they ascribed to team-based learning. As a consequence of this, teachers explained they experienced a more positive teacher-student relationship and classroom environment where discipline and classroom management were less of an issue for many teachers, with a more trust-based teacher-student relationship emerging.

Computer Science, the PG Cert and the TA21 schools

Teachers from the TA21 schools who participated in the PG Cert developed more confidence and intention to use technology in their teaching, they increased their use of collaborative teaching practices and were ascribed more value to CS at the end of Year 1. This increase in skills and value led to 72% of the TA21 schools committing to a 3-day in-school CS programme that integrated digital media, CS with the existing curriculum. Furthermore, as a direct result of participating in the CS workshops aspect of the PG Cert five of the eleven participating schools have implemented a coding course within their school. One school has included coding in their curriculum and has chosen to remove another subject in order to facilitate this within the schedule. Teachers from within these schools have also been involved in external CS events, for example, one girl’s school had their transition year students complete a Code-Plus programme in Trinity College Dublin.

![Figure 6: Increase in frequency of 21st century teaching practices](image)

### The Case Study 2: Student discovers “I want to study CS”

Stacey is 15 years old and attends a DEIS school in the greater Dublin area. Through her contact with TA21, and the CS activities, associated with the project, Stacey has developed a keen interest in CS and sees this as a possible avenue for her future career. Here is her story.

“At first, TA21 didn’t really bother me that much probably for the fact that I didn’t grasp the objective of it thinking it was just another random event our school got put into. But when we started getting more and more in depth of the whole idea of it, my impression of this project changed.

Being the ‘first’ ever year in school (school name) to do this is an honor, it helped each individual be a better self, and more importantly, recognize our own selves more by opening up our eyes to possibilities we couldn’t have thought of without the help of this project. TA21 exposed us to the outside world and to the future helping us prepare mentally.

I think TA21 helped me develop in a lot of areas. One of them is participation. I barely joined any clubs or groups in school, but with TA21, someone (always) has to step up in order to achieve something. As a student who doesn’t really have a clear perception of her ambition it really helped me because of this project, I got to join in a lot of clubs and camps: I joined the STEM Easter Camp with the help of my science teacher and later on went back to the STEM Summer camp which I really adored.

STEM (Science, Technology, Engineering and Maths) may not appeal to a lot of students, but I would love to be involved in one of them in the future! CFES links in with STEM when we were doing our career activities. At the start I was clueless, but after joining the camp, I immediately researched the STEM sectors, and now I am almost definite I’ll be involved in one, or as I’ve said all of them in the future.”


The impact of the STEM/CS element of the PG Cert can also be seen in the effect it has on students’ college and career plans. Case Study 2 gives a student example of how being in a school, which has committed to participation in TA21, has changed the student’s career aspirations and made STEM/CS a real goal for her future.

Accreditation and motivation
The PG Cert placed greater emphasis on the importance of technology-mediated learning, gave teachers more confidence in using technology in their classrooms and in their ability to use it effectively to achieve learning outcomes. For a number of teachers, participation in the accredited PG Cert facilitated the adoption of less traditional teaching and learning approaches, and created a driver for them to change their professional practice, particularly in light of fulfilling the assessment requirements for the programme. Teachers identified a number of outcomes for students, including a greater level of enjoyment, enhanced confidence in respect of the digital skills associated with making videos and other digital artefacts, enhanced confidence in respect of presenting their work, becoming more responsible learners and taking on differing group roles, being able to think for themselves and becoming better problem solvers, developing an enquiring culture and research skills, as well as sharing ideas and working collaboratively.

Barriers
While there have been clear gains in terms of teachers’ attitudes toward technology and its use in the classroom, barriers have been identified which prevent a deeper embedding of 21st century technology-mediated teaching practices within the schools. The restrictiveness of traditional school structures continues to impact attitudes to technology and its perceived value in every day teaching. For example, one teacher stated that her excitement about the possibilities were dampened by her every day classroom experience, she states “I’m excited about the possibilities I’m reading about but I’m not seeing a lot of them in the actual system and that’s the curriculum ... it’s still very much focused on how to play the system and how to get the points to get into college and the kids are learning things off...that sort of rote learning student because of what they have to do at the end of the year”. Similar to the STEM/CS findings, the main barriers to change are teaching to the test, 40-minute class times and a strict curriculum.

Case study 3 provides an example of where change can happen if the whole school is prepared to participate in the change. This school extended their class times to one hour and included a coding module in the curriculum. They also allocated planning time to staff so that technology-mediated learning could be incorporated into the curriculum. The teachers meet regularly to discuss how the classroom content is being applied across the curriculum. This has resulted in a happier school environment, and a real sense of uplift in the school community.

“CPD that is accredited is fundamental to change.”
(Principal 1)

“Class time, planning and teaching to the test are limiting wider change.”
(CS STEM Teacher 3)
Case Study 3: Whole School Change

St Joseph’s Secondary School, Rush, has seen its progression rates to further education increase in recent times. In 2014/2015 13 teachers participated in the PG Cert, and several others availed of the STEM/CS workshop offerings. In 2016, Patricia Hayden, the Principal, took the decision to extend the class times to one hour to facilitate the use STEM/CS content in all subjects, they also introduced coding into the curriculum in place of another core subject. This is the school’s story.

St Joseph’s Secondary School, Rush, has been involved with the Trinity Access Programme since 2007. From 2007 until 2013 one guidance counsellor, with the support of the principal and deputy principal, led the access programme. Year by year, there was an increase in the percentage of students progressing to third level. However, the guidance counsellor and senior management seemed to be constantly fighting a rear guard action to convince colleagues that our students had innate ability and creativity, which heretofore had not found expression in school. It was not until 13 teachers availed of the PG Cert that there was a fundamental change in how teachers motivated and inspired students.

This change was gradual at first; students were to be found roaming the corridors with iPads and phones making movies of maths problems or scientific phenomena. Then there was talk of designing websites and, something new, coding! Most remarkable of all was that the staffroom became a place where teachers talked about their latest assignment and gave each other tips on how to use this or that piece of software.

As principal, I watched and listened as 55 teachers and 700 students learnt a new language. The thing was that the guys with the technology were doing interesting things. The students were delighted and enthused; they liked what they were doing and generally conversations were about “how”. I heard 1st year boys discussing their “oral language presentations” at break time on the corridor. Teachers used technology to teach and assess their students. They asked their students questions about how they were learning and how the teachers were teaching. The school developed the reputation for being innovative and happy.

Now the school offers Coding as a Junior Cycle subject in first year, TY and we have a coding club. Cooperative learning methodologies are the norm for most teachers. We introduced one-hour classes this year to allow for more active learning to take place. 75% of teachers say they are using more active teaching methodologies.

One teacher on the PG Cert became interested in Student Voice. He has led what can only be described as a movement in our school. The students have developed a vocabulary, which enables a conversation about their own learning with teachers and others. Student Voice has been transformative for the young people in our school. Their motto is ‘Nothing about us without us!’

It isn’t an exaggeration to say that the school’s involvement in TA21 has been life changing for students and teachers. It has firmly established a culture of innovation, creativity and curiosity in our school.
Summary of Teacher Results

Participation in the PG Cert and the STEM/CS workshops has had a positive impact on teachers in several ways, these include;

- Following participation in the PG Cert, teachers demonstrated higher confidence to teach Scratch, Python and Raspberry Pi in comparison to teachers who did not participate
- Teachers report using STEM/CS content for an average of 26 hours a year in their own teaching
- Teachers estimate that, on average, 26 students have benefitted from their participation in STEM/CS workshops
- Teachers who participate in STEM/CS are more likely to look for further STEM/CS CPD offerings
- 63% teachers who participated in the STEM/CS workshops said they have introduced new CS content in their classroom as a direct result of participation
- 4800 students in TA21 schools participated in at least one STEM/CS classroom activity in Year 1
- Teachers are more confident in their ability to use technology in their teaching
- Teachers ascribe a greater value to the role of technology in their teaching
- Teachers are more comfortable creating an environment where students can be creative and innovative with a variety of media, where students can communicate differently while using these media and allowing students to be self-directed in this regard.
- Teachers demonstrated an increased confidence in their ability to use collaborative, technology-mediated teaching methods.

Through an examination of the TA21 research, three types of teachers have been identified. Each type of teacher has different needs and different pathways toward a more STEM/CS-focused classroom environment. The research suggests that when these different needs are supported teachers are more comfortable to implement STEM/CS focused 21st century teaching and learning practices within their classrooms.

Figures 7 and 8 identify the journeys of the three teacher types identified through the Year 1 research. Teacher A is the teacher who chooses not to participate in any STEM/CS related CPD. This teacher is often older, has been teaching for a significant period of time and does not see the value of ICT in the classroom. In Figure 6, Teacher A stays low in value and low in adoption of ICT in the classroom. Teacher B starts out with an understanding of the value of technology and STEM/CS in their teaching, and looks for CPD that will help develop their skills. Teacher B develops confidence and intention through accredited CPD. However, if the barriers are too large or there is no support from leadership in the school, then their level of ICT adoption slightly increases but they do not move into more advanced programming teaching. If Teacher B has support from leadership, and can overcome the barriers of time and structure they often look for further STEM/CS CPD and develop coding clubs and other activities within their school. Teacher C is already skilled in STEM/CS and has a high value in ICT in the classroom. This teacher will skip the accredited CPD and go for the advanced coding supports. Teacher C will often act as a leader within their school and will be a strong advocate for change.
Indications from Year 1 Findings:

1. Teachers need to see the value of ICT before they will participate in the CPD. Making the content accessible and relevant to their needs is a way to achieve this. Incentives such as more time and support for training may also increase this value.

2. Teachers are generally motivated to include ICT in their classroom; the barriers to change need to be addressed for these teachers to develop their expertise. This would include:
   - Extending class times to allow for project work to take place
   - Investment in STEM/CS resources across schools
   - Including coding in the curriculum
   - Making STEM/CS relevant to the current examinable subjects and allowing teachers time to understand this process

3. Teachers who already have a good knowledge of STEM/CS need to be incentivised to lead change within their school. Some teachers are considering other professional options because of the pace of change in the system. Removal of the barriers identified in the previous section would support these teachers in leading whole-school change in their schools.

Figure 7: Teachers’ journeys with ICT

Teacher A:
- Teaching in school for over 20 years
- Has no confidence in using technology for teaching and no desire to learn
- Sees time, tests and subjects as incompatible with technology implementation
- Makes no changes to teaching unless intervention is designed to increase value of technology in teaching

Teacher B:
- Sees the value of technology in teaching but has low confidence
- Participates in accredited CPD (PG Cert) and grows in confidence to use technology in teaching
- Adapts teaching practice to incorporate some technology use but little confidence in more advanced techniques
- Attends more specialised CPD and begins to implement coding more regularly in the classroom

Teacher C:
- Is confident with technology in teaching
- Participates in more advanced in STEM/CS workshops
- Does not need accreditation to be motivated to participate
- Leads whole-school changes; e.g. piloting of Junior Cycle short course in coding
- Encourages other teachers to participate in CPD offering

Figure 8: Teachers’ adoption of ICT in the classroom
485 teachers participated in STEM/CS CPD workshops in 2014/2015.

Research Findings: TA21—CFES

11% increase in student’s intention to pursue higher education.

22% increase in students’ intention to enter lower and higher professions.

Students were more positive about their school experiences and relationships with teachers.

Students were more confident in their ability to navigate higher education.
Table 2: CFES Project Constructs and Core Practices

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Pathways to College</th>
<th>Mentoring</th>
<th>21st Century Teaching and Learning</th>
<th>Leadership through Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concerns about costs</td>
<td>Informs students about funding and costs</td>
<td>Mentor provide their experience of finances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concerns about careers</td>
<td>College course and career investigations. Campus visits and meeting professional</td>
<td>Learn about mentors job opportunities</td>
<td>Exposure to different learning environments, skills and professions</td>
<td></td>
</tr>
<tr>
<td>Networks</td>
<td>Relationship with role model with whom they can identify provides new basis for action</td>
<td></td>
<td></td>
<td>Networks within the school and community through service</td>
</tr>
<tr>
<td>Trust</td>
<td>Completing college activities with mentors build trust</td>
<td>Relationship with mentor builds new trusted information</td>
<td></td>
<td>Networks within the school and community builds trusted information</td>
</tr>
<tr>
<td>Information</td>
<td>Providing college and career information, along with access to college campuses, aims to change the narrative about college within the school and the family networks</td>
<td>From mentor and teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence</td>
<td>Information about access progress and course increase confidence in own ability through self reflection</td>
<td>Affirmation and support Role model builds confidence</td>
<td>Accredited CPD build teachers confidence Participating in new learning environment build student confidence</td>
<td>Leading and service build esteem and autonomy</td>
</tr>
<tr>
<td>Skills</td>
<td>Communication</td>
<td>CPD –increases teachers coding and technology Students experience new learning environment</td>
<td></td>
<td>Leadership and collaboration</td>
</tr>
</tbody>
</table>

19
TA21-CFES Background

As a member of the European Union, Ireland has set a target for 72% percent of students to pursue post-secondary education. Fifty-two percent of Irish young adults (18-20 year olds) now progress to higher education following completion of the final state examination, and their progression rate within higher education averages 85%. While overall higher education progression rates in Ireland are strong, some socio-economic groups and particular geographical areas have much lower than average participation rates in higher education. A recent report by the Higher Education Authority indicated that students in under-represented socio-economic groups require more professional role models, career-focused guidance counselling, a culture of high expectations, and an active learning environment to support the development of college-going expectations.

The TA21-CFES aspect of this project attempts to effect change in the progression rates of low-income students through three core practices Leadership through Service, Mentoring and Pathways to College, alongside a fourth practice focusing on 21st century Teaching and Learning. This project is adapted from a US non-profit CFES (www.collegesfes.com), and builds on an extensive evidence base which shows that these constructs are essential for educational uplift.

TA21-CFES Findings

The following section reports findings from Year 1 data focused on students. The analysis compares the TA21 students, with the TAP control group and the High control group. Year 1 of the TA21-CFES project required students to participate in Mentoring, Pathways to College, and Leadership through Service. These activities are described in Appendix A. Table 1 demonstrates how TA21-CFES meets the challenge of academic capital formation and describes the core competencies affected by participation in the project.

1. College Knowledge

Students were asked to complete questions about how they felt their school was preparing them for higher education as well as how confident they felt to navigate the college system. Overall, the TA21 students rated their schools significantly higher at the end of Year 1 compared to the start of the year in terms of making them college ready, providing information about entry requirements and financial supports. They also rated their schools higher in creating a college-going culture and teaching them how to succeed in college (Figure 9). There was a decrease in these ratings for the comparison groups.

2. College Aspirations

Students were asked to specify what they planned to do after they completed school. They could choose more than one option. They were asked about completing a trade, completing a 1-2 year further education course and completing a 4-year degree. At time one, a higher percentage of TA21 students and TAP students planned to complete a trade and further education course, compared to the group with high progression rate to post-secondary education (Figure 9). However, following one year of TA21, the TA21 group had an increase of 12% in students who stated they intended to do a degree when they completed school. This is 9% greater than the High control group at time 2 (Figure 10).

Figure 9: Average rating for college preparation across the groups

“Because of this project I joined the STEM Easter Camp with the help of my science teacher and later on went back to the STEM Summer camp which I really adored.” (CFES Scholar)
3. Career Plans

Students were asked to select the careers they think they would like to pursue after school, and were allowed to select a maximum of three occupations. These were categorized by socio-economic groupings. Not surprisingly, the High control group selected higher professional occupations more than the TA21 group and the TAP group (Figure 11).

Following participation in the TA21 project, there was a 10% increase in the TA21 students stating they were considering careers in the lower professional category (teacher/engineer) and there was an 11% increase in TA21 students stating they were considering jobs in the higher profession category (careers that require a college degree) (Figure 9). These increases were not evident in the TAP group or the High control group suggesting they are a consequence of participating in the TA21 project.

There has been variation in the successful implementation of TA21-CFES across the schools. Following Year 1, it is clear that the most important ingredient for success in a school is the support of leadership and management. When the leadership is supportive, this ripples out to the staff, students and the wider school community. Furthermore, through integrating TA21-CFES into all subject areas, departments, key posts, timetabling and running branding campaigns, the project and its objectives take root at the very heart of a school’s ethos. Providing time for adequate planning and reflection cultivates continuous learning and a burgeoning college-going culture.

**Indications from Year 1 student research:**

- Students happier in how the school is preparing them to get into college and navigate the college system
- 11% increase in students intending to progress onto university following one year of TA21-CFES
- More students intending to pursue careers that require a third level education

**Figure 10: Students’ post-secondary plans after Year 1 of TA21**

**Figure 11: Career plans for students’ pre- and post-TA21 year**
Conclusion

There are encouraging outcomes from the first year of TA21. The scale of interest in the PG Cert and STEM/CS workshops has been impressive, particularly as this has involved an undertaking to complete the course at weekends, out of regular school hours. While participants in the first year of the course were limited to the schools participating as project partners, there were applications from over 80 schools across 16 counties nationwide in the second year.

Key observations from year one have been:

- Over 550 teachers participated in some type of STEM/CS CPD in 2014/15.
- Participation in the STEM/CS CPD offerings increased teachers confidence to teach computer programming and to use ICT to enhance their classroom experience.
- Over 4000 students had at least one STEM/CS classroom experience as a direct result of teachers engagement with TA21.
- The level of 21st century teaching practices in the classroom increased as a direct result of the PG Cert offering. Students were more likely to lead projects, collaborate, and use technology creatively in a self directed manner.
- Being a part of the TA21-CFES affected students college and career plans; with 100 more students intending to progress onto college following year one, and 220 students planning to pursue careers that require a college education.

However, there are some limitations identified to implementing change in teaching and learning. These are:

- Class times
- Teaching to the test
- Resources

However, teachers in affluent schools, or schools with supportive leadership structures were able to overcome these barriers and develop innovative STEM and CS student experiences.

Since year one, the TA21 project has begun to develop a digital tool-kit to scale the use of project resources. These have been used by a range of new schools alongside consultation with the project team. Many of the teachers who have completed the PG Cert in Year 1 and 2 are continuing to pursue their professional development by undertaking Masters level, and in some cases, PhD level study, and a third cohort for the PG Cert is currently being recruited.

It will employ the following strategies to make these changes:

1. Scale teacher participation in the PG Cert and STEM/CS workshops and build partnerships with more schools, sponsors and post-secondary institutions nationwide.
2. Develop a structure within the eleven project schools which embeds STEM/CS into the existing curriculum: this includes lesson plans in subject areas deemed ‘less suitable’ to STEM/CS content.
3. Create a digital toolkit, which contains examples of best practice, for teachers to use as a resource: this includes lesson plans, student resources and innovative ideas.
4. Develop a national school of distinction award: this will reward schools who demonstrate excellence or innovation in several areas. These include whole school implementation of STEM/CS, college and career awareness, mentoring, special education, parental involvement.
5. Support schools to develop stand alone STEM/CS courses that can run during the school day: this will speak directly to the junior cycle short course in coding.
6. Scale the student STEM/CS classroom experience through supporting teachers to develop these skills and embed them in the classroom.
7. Continue to build an evidence base that speaks directly to national policy and structures.

This project has been supported by Google Ireland over the 2014-17 period, providing invaluable resources and strategic input but also complete autonomy to the TA21 team to develop and implement the project. We are grateful for the opportunity to build this exciting intervention with all our partners and to see it come to fruition, to the benefit of thousands of young people currently in our education system.