An IoT and Wearable Technology Hackathon for Promoting Careers in Computer Science

Jake Rowan Byrne, Katriona O'Sullivan and Kevin Sullivan

Abstract— **This paper explores the use of a constructivist 21st Century learning model to implement a week long workshop, delivered as a "Hackathon", to encourage pre-university teenagers to pursue careers in STEM (Science Technology Engineering and Mathematics) with a particular emphasis on Computer Science. For Irish pre-university students, their experience of computing can vary from word-processing to foundational programming and, while many schools are looking to introduce more ICT into the classroom, many students are left with a narrow view of what Computer Science is all about. Twenty one students participated in the workshop and completed pre and post surveys, and free word association with the areas of computing and careers in computing. Analysis revealed that students motivation to learn about the design process, programming, Inputs and Outputs and Wearables Technologies/Internet of Things (IoT) increased following participation. There were also increases in confidence in Inputs and Outputs and Wearables Technologies/IoT following participation. There were changes in the computing word associations following participation, with students associating computing with more computer programming terms rather than more general terms such as the internet. The findings suggest that the combination of a "Hackathon" event and a model for 21st century learning can be effective in motivating and increasing the self-efficacy of pre-university teenagers in a number of emerging technological contexts such as IoT and Wearables.**

Index Terms— **Computer science education, Internet of Things, Wearable computers, Robotics and Automation, Teamwork, Problem Solving, Prototypes**

I. Introduction

THE use of "Hackathons" [1-3] and hackathon-like activities are a growing trend to promote engagement in STEM activities, but there has been limited work to date that has explored how they can be harnessed for pedagogical outcomes [2]. Furthermore there has been some research that has explored changes in students perceptions of Computer Science after engaging in a hackathon activity [3], but the details are limited and suggest further research is required.

This paper was submitted for review on the 5th of October 2015.

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This work will examine students' perceptions of, and attitudes towards, computer science, before and after engaging in a collaborative computing workshop involving both software and hardware, structured as a wearable technologies [4-6] and Internet of Things (IoT) [7, 8] "Hackathon".

The aim of the workshop is to give students a greater appreciation of what computing can involve in practice and to introduce them to programming hardware interfaces for real world problems.

Bridge21 is an education project that aims to develop and promote an innovative, 21st century learning methodology in schools through a social constructivist pedagogy. This workshop was delivered using the Bridge21 pedagogical model for collaborative, technology-mediated, project-based learning [9, 10].

The participating students all had previous Bridge21 workshop experience in which they became familiar with the model and had learned some programming skills using tools such as Blockly and Scratch [10]. These technologies are designed to introduce programming concepts and functionality to novice programmers. The students also experimented with alternative human computer interfaces using the Windows Kinect and Makey Makey, and other devices.

This study focuses on a workshop which builds on these experiences by focusing on Wearable Technology, IoT, Robotics and Home Automation. The format was a four day hackathon where each team had to prototype and develop a marketing strategy for a "product" by lunchtime on day four.

In the course of the workshop students worked in teams and took on various roles covering the technical, creative director, marketing and project management. Using a range of technologies, each team built full or partial models, including software, for their ideas. They also created a marketing campaign and the workshop culminated with each team making a Dragon's Den/Shark Tank style pitch to "sell" their idea.

II. Background

A. Projects for Promoting Careers in STEM

STEM education is a much discussed topic [4, 8, 11-14] as countries move towards an information society. The literature in this area vary from practical projects [4, 10, 12, 15-17] that outline learning experiences and approaches to those that talk about STEM education as a phenomenon in general [8, 13, 14]. Although there are differing views as to what is the best approach to take, integrative, problem/solution or enquiry based learning, there is consensus that there is a need for more STEM graduates.

Roberts [18] argues that STEM education is more than teaching STEM domain knowledge but also requires the inclusion of 21st century "soft" skills such as, teamwork, creativity, problem solving and inquisitive thinking. Roberts also emphasizes the need for learning of domain knowledge through *"authentic problem solving in rich social, cultural and functional contexts".* These are all necessary to prepare learners for the ever shifting landscapes that are found in STEM disciplines.

B. Hackathons

A hackathon can be described as an event, usually 24-48 hours in duration, that involves a team-based "problem-focused computer programming" activity [1]. They usually involve prototyping some digital artefact and pitching or presenting that prototype. One of the motivating factors in a hackathon is the focus on a social or cultural issue that has some significance to the participants. The hackathon phenomenon seeks to combine both the "authentic problem solving in rich social, cultural and functional contexts" and the rich team dynamics that Roberts argued for.

A number of works have made some attempt to explore pedagogical approach in hackathon-like activities [2, 19, 20]. These fall short on the pedagogical underpinning as they are largely exploratory in nature and have limited theoretical and practical basis. They do however suggest that hackathon-like activities can offer a novel approach to designing practical and contextualized learning experiences.

It has been suggested that activities that emphasize creativity, design and problem solving are well suited to contextualize STEM subjects for diverse groups of students [21]. A focus on real world problems is central to this approach. The desire for diversity and reach has led to a number of different hackathon-like approaches to try and engage pre university students in STEM subjects [22]. Hackathons, and other "maker" events that focus on real world problems, have been used to promote diversity in computer science by promoting female engagement [23], one such approach would be the inclusion of wearable technologies as a problem area [6, 24].

Hackathons therefore provide an excellent framework within which to develop effective and inclusive STEM activities but this approach does not explicitly deal with how to support 21st century skills

C. 21st Century Learning

There is a wider push for reforms in education towards 21st century skills [25, 26]. These reforms are generally aimed at making education provide more opportunities for developing key skills such as teamwork, effective communication and thinking critically [27]. In order to facilitate the 21st century learner there is a need for educational practices to move to a more student centered approach. One such approach used successfully in providing 21st century learning experiences in a Computer Science context is the social constructivist Bridge21 Model [10].

III. DESIGN

A. Bridge21 Pedagogy and Model

The workshop was based on the Bridge21 model for 21st century learning which emphasizes teamwork, learning by doing and technology-mediated project work [9]. The Bridge21 pedagogical model is a social constructivist approach that has been used in post-primary schools in the Republic of Ireland over the last 9 years, and has been adapted for use in a wide range of subjects such as history [28] and mathematics [29]. The model was designed to foster intrinsic student motivation and learning potential through a deliberate move away from teacher-led learning [30]. Furthermore a social constructivist approach includes discovery learning, problem solving and collaboration. In this approach the role of the teacher is to facilitate the learning, encouraging students to problem-solve and think for themselves. Here Vygotsky's [31] idea of a "more able other" is leveraged through peer learning and mentorship. Similar constructivist approaches have been used to design both formal to informal learning experiences particularly when it comes to working creatively with computer programming [32].

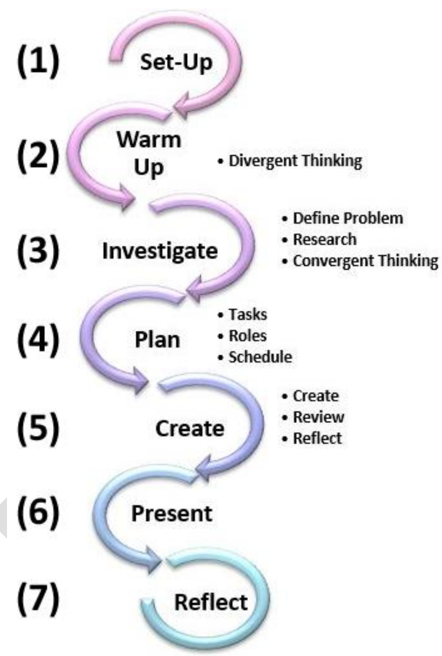

Fig. 1. The Bridge21 Activity Model. Describes the generalized form a Bridge21 activity follows, this can be compressed or expanded depending on content to be covered.

B. Bridge21 Activity model

The Bridge21 pedagogical model outlines the contextual elements required to deliver and facilitate an effective 21C learning experience; however it does not describe how to structure and design activities. The Bridge21 Activity Model (Fig. 1) consists of seven stages to be considered when developing a 21st century learning experience. The activity model is adapted from practice and integrates elements from design thinking [33, 34] where teams move through phases of inspiration, ideation, and implementation. Although traditionally conveyed as a linear or cyclical process, the reality is that design thinking allows for a non-linear approach where the teams can go back and revise previous phases if required [35]. The linear/cyclical layout provides a reminder that all stages are required and should be included in order to develop a comprehensive solution.

The Activity Model was used in the development of the Hackathon activities discussed in this paper.

C. Before the Hackathon

All of the students had previously attended Bridge21 workshops so they were familiar with this approach. During their previous Bridge21 workshops [10], the students were introduced to computer programming with Lego Mindstorms, Blockly and Scratch. They moved from simple procedural programs, through to more complex animations and ultimately to designing and building games. Through this process they were introduced to computing concepts such as initialization, parallelization, looping, conditional statements, Boolean algebra, variables and crucially, testing, debugging and refining their programs. They also had their first chance to work with inputs other than the mouse or keyboard by using the Windows Kinect, Nintendo Wii or the Makey Makey. Each team finished the week creating a Scratch game that would be controlled using one of these.

This experience allowed students to solve problems and create artefacts in a way they had not done before. They learned new technical skills, but there was also a strong emphasis on the skills mentioned by Roberts such as teamwork and problem solving. Confidence in these areas was an important pre-requisite for the workshop described in this paper. This workshop is a next step for students that want to further develop their computing, project and collaborative skills.

D. Hackathon Challenge

The design of the week was largely inspired by the hackathon movement. A traditional hackathon would normally involve teams of professionals working over an intensive 24-48 hour period. Due to working with a younger demographic, with a more limited set of technical skills, there was a need to make some changes to the traditional hackathon delivery approach. The study was spread over a week due to the fact that the minors were only able to be facilitated with their work from 9:30am to 3:30pm each day. The first day also provided a more traditional educational workshop that introduced the basics of inputs and output using Python and Raspberry Pi computers. This first day could be seen as separate to the main hackathon activity. During the following three days the teams worked more independently. They used design thinking to come up with their own idea, prototype it and finally presented their concept on day four. The last three days are more in line with a hackathon approach, where real world problems are tackled leading to a prototype idea using the available resources. In line with the social constructivist approach there is a greater emphasis on the processes the students work through rather than just a complete or finished product.

E. Technical Infrastructure

Each team had access to the following technologies. A Raspberry Pi [36] running Raspbian OS with an Apache webserver, PHP and Python. Also available were Arduino Uno [37] boards, a robotic vehicle chassis with onboard motor controller and Grove [38] add-ons for both Arduino and Raspberry Pi and a wide range of inputs (heart-rate sensor, light detector, switch etc.) and outputs (L.E.D.s, servos, sound etc.).

Each team also had a camera, microphone and two networked Microsoft Windows PCs available to them throughout the week in a dedicated team "pod" (Fig. 2). Having only two computers per team is intentional [39] and aimed at promoting communication and collaboration to complete tasks. This approach also promotes paired programming, which has been shown to improve students' confidence in programming and may also help promote diversity [40].

Fig. 2. Teams working on their prototypes. The Bridge21 learning space, where team "pods" can be seen in the image on the right. The image on the left shows a team sketching out pseudo code for their heartrate monitor and the image on the right shows a team testing their robot on the floor.

F. Mentoring and Facilitation

Throughout the hackathon there was one lead facilitator and three mentors present. The lead facilitator had a background in mechatronic engineering, while the other three mentors had a computer science background. This was a ratio of five to one. The mentors were not assigned to any particular group and were advised to only intervene if help was requested. This was to promote student ownership of the problems and to simulate requesting expert advice, as one might in industry. This approach complements Vygotsky's [31] idea of providing a more able other, to help where needed but to also step back when not required. Technical knowledge and solutions were provided by the mentors, but care was taken to guide the participants towards the solutions and model the process rather than simply providing solutions.

G. Hackathon Structure

As the Hackathon took place over a four day period, each day was designed to progress the students towards completion. Day one was used to deliver the technical knowledge required to engage meaningfully with the task of developing a Wearable, IoT, home automation or robotic solution by the weeks end. Therefore the first day focused on stages 1-3 in the Activity Model, largely exploring domain knowledge as part of the investigate phase.

Day two focused on developing and planning what they were going to design and prototype, based around a future technology workshop [41], they also started making; stages 3-5 in the Activity Model.

Day three was largely dedicated to phase 5, the creation stage. This phase involved the development of both a working prototype and a digital media campaign to promote their idea.

The fourth and final day focused on final modifications and the presentation of their work, followed by some reflection on what was learned during the week; stages 5-7 in the activity model.

1) Day One – Domain Knowledge

Day one started with a (1) '*set up phase'* in which teams are formed and introductions were made. Effort was made to create gender balanced teams. Mixed ability would normally be sought, but this group was relatively uniform as they had similar prior experience from the previous workshops. This was followed by a (2) *'warm up'* activity which was designed to encourage divergent thinking. The teams are asked to brainstorm examples of computers in everyday life, with an emphasis on inputs and outputs. Examples included applications such as house alarms, ATMs, dishwashers and smartphones. This activity got the teams working together and thinking creatively. Next, the (3) *'investigation stage'* promoted convergent thinking and sets the context of the activity and makes up the majority of this workshop session. Here the teams were introduced to Python via an exercise that built on their previous knowledge of the Scratch programming environment. They were asked to find the Scratch equivalent to a list of Python commands. Once all commands had been translated, the teams were tasked with solving five progressively more complex Python problems. The commands needed to solve these tasks were present on the Python-Scratch translation sheet, enabling them to select commands from a list, in a similar fashion to the Scratch interface.

On completion of this task the Python General Purpose Input Output (GPIO) library was introduced and they are tasked with wiring up an LED and switch and using a Python program to activate the LED when the switch is pressed.

Finally, they are presented with some code that activates the Python Scripts using some PHP code run on an Apache webserver on the Raspberry Pi.

There was a final discussion to elicit the fact that the basic elements that had been explored that day, namely the general use of Input and Output, are used in computers all around us in modern life. It was also highlighted that the Raspberry Pi can be easily used to model a variety of Input and Output actions with the added benefit that it is easy to connect to the internet, enabling web connected objects, remote home automation and robotics and ultimately the Internet of Things.

This day could be seen to align most closely to traditional STEM programmes where all students are expected to engage in largely the same activities and output the same results.

2) Day Two – Design Challenge

As previously stated the four main topics for the week were Wearable Technology, Internet of Things, Robotics and Home Automation. Building on these themes the teams were asked to brainstorm under the four headings. There were boards placed around the room and individuals could add a post-it note to the board under each heading. The teams then went around and reviewed the collective ideas from the whole group. They were then asked to choose three ideas to implement and weigh up the pros and cons. These pros and cons were then discussed with a facilitator after which the team choose a specific design to proceed with prototyping. The facilitators played a part at this stage managing expectations and helping the teams decompose their problem down to an achievable prototype that would capture the essence of their overall "product" idea.

The teams allocated roles and started gathering the components and technologies needed to realize their ideas.

3) Day Three – Prototyping

This day was mostly dedicated to prototype development. This involved programming, making electronic circuits, building models with Lego and other craft materials and working with robotics kits. This learning by doing approach is typical of many social constructivist pedagogies. Teams were also encouraged to start thinking and developing their pitch. This involved the production of the videos and websites needed to market their product. This day largely focused on the iterative nature of phase 5 of the Activity Model: Create, Review, Reflect.

4) Day Four – The Pitch

The team members took on various roles covering technical prototyping, multimedia development, marketing and project management throughout the week. The more technically inclined students drifted towards the programming and electronics and those interested in graphic design and multimedia focused on developing video adverts and websites to promote their product for the "pitch". This differentiation was deliberate. The goal of the programme was to expose all students to the work involved in a range of potential careers in computing. As a result there was a desire to have a variety of applicable roles, including softer business and marketing elements and more in-depth technical fields such as programming and electronics. This approach provided all team members with the opportunity to engage in a technical project, but from different perspectives, representative of real world projects. This is contrasted against many other educational programmes where every student would largely engage in very similar tasks.

The students then presented their prototypes alongside their websites with embedded video adverts to a number of academic staff from the University. The academics were selected in an ad-hoc fashion from the Computer Science department and questioned the teams about the technical elements and what their market would be. There was no prize for the "best" product as the aim of the week was to encourage all participants to pursue Computer Science and having the majority of the cohort "lose", would not be conducive to this aim. The Bridge21 approach also aims to develop intrinsic motivation and prizes, as extrinsic rewards tend to undermine the development of extrinsic motivation [42].

This pitch was a fundamental part of the workshop as it gave a deadline for the prototype development but also provided an opportunity for the teams to hone 21st century skills such as communication and presentation.

Finally the teams were given a sheet on which to reflect on their learning and teamwork. This was followed by the post questionnaire and word associations.

IV. Methodology

21 students participated in the hackathon workshop and completed the research after having completed previous Bridge21 introductory computer science activities. These participants were invited to participate in this study due to their expressed interest in Computer Science. As result a comparison group of 21 students were recruited from non-computer science Bridge21 activities in order to explore how the main workshop participants compared to a more general population. Ethical approval was sought and granted by the appropriate authorities and as all participants were minors, informed consent forms were completed by the participants and their guardians.

The hackathon group and the comparison group were balanced for gender and both consisted of 9 females and 12 males. The mean age of students in both cohorts was 16. The comparison group of students were opportunistically recruited. The experimental group was self-selecting and signed up to this workshop based on interest. Both groups had high level of prior experience with the Bridge21 model. The comparison group however had limited prior experience in terms the computer science workshop as described in section III C.

Pre and post questionnaires were adapted from existing studies [12, 16, 17] and sought to investigate students' attitudes to several aspects of the workshop content using 8-sub scales. The pre questionnaire was completed online at the start of day one and the post questionnaire at the end of day 4. The questionnaire used 33 statements (e.g. 'I like to work with others to complete projects') and a 5 point Likert scale with 1 as strongly disagree and 5 as strongly agree, to establish changes in students' motivation and self-efficacy in Programming, Design, General Purpose Input Output and IoT/Wearables. It also examined students' perceptions of their team-work and problem solving capabilities.

Centra and Gaubatz [43] suggest a strong connection between students perceptions of a learning experience and the "actual" learning that takes place and may be subsequently tested. Although the study is not explicitly evaluating the learning content of the hackathon in this research, there is a potential link between their self-efficacy and motivation and the learning of technical content during the week.

Other qualitative questions used free word-association [44-46] as an indicator of students' attitudes and perceptions of careers in computer science and computing in general. This approach generates spontaneous responses that may not be elicited from more structure interviews or questionnaires. For the word association, the participants were asked to list five words they associated with both computing and five for careers.

The students' work was also analyzed with a view to determining which computing themes and which technologies the students chose to use and to examine the level of complexity of their technical work.

V. Data

As stated, the adapted questionnaire, which sought to investigate students' attitudes to Programming, Design, GPIO and IoT/Wearables, was administered to 42 students at time one (pre participation in workshop).

1) *Prototypes*

There were five prototypes developed by the four participant teams, along with a website and video to promote each product. The products covered the full spectrum of topic areas that the workshop focused on: Wearable Technology, IoT, Robotics and Home Automation. Each teams' output artefacts (code, images of prototypes and videos adverts) were collected in a folder and reviewed in order to explore the technologies utilized.

"BetaFit" was a wearable personal fitness tracker and website/app. This team decided to focus on prototyping the heart monitoring functionality and relaying that information to a website. This was achieved using an Arduino and Grove heart rate sensor as the hardware. This wrote the data to a file on the Raspberry Pi which was dynamically loaded by PHP script and visualized on the website using highcharts.js JavaScript library.

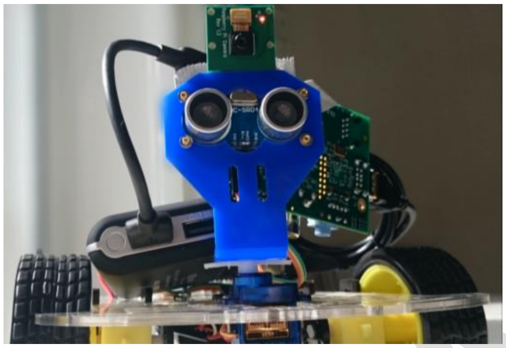

Fig. 3. "The Bridge Rover", the Raspberry Pi camera can be seen above the ultrasonic "eyes". A portable battery and Raspberry Pi computer can be seen connected in the background.

"The Bridge Rover" (Fig. 3) is a home security robotic that can be controlled over the internet. The prototype consisted of a Raspberry Pi, Raspberry Pi camera and portable USB battery mounted on an Arduino controlled chassis. The image from the camera was relayed to a website using Mjpg-streamer open source software. Controls were built around the image using basic HTML buttons and jQuery AJAX calls to PHP scripts that sent commands to the Arduino. The students were using a mobile phone to view and control the robot remotely.

"BrijjFrijj" is a smart fridge that can detect if any of the contents has passed their "best before date(s)" or is finished and needs to be reordered over the internet. The prototype consisted of a Raspberry Pi with MySQL, a mobile phone, NFC tag and a Lego Technic and Mindstorms kit. A model fridge was constructed from Lego, the phone was attached to the door of the fridge to act as a NFC tag reader. The NFC tag was attached to a milk carton so that when it was swiped across the door when putting it in the fridge the phone launched a browser and pushed meta-data about the best before date and product type to the MySQL database. A webpage could then be loaded to display the status of the content, with a mock button for ordering a replacement item if the date had passed.

"EyeGlove" (Fig. 4) is a wearable smart glove that has a built in torch, a heating and cooling system, and connects to your phone to play music and make telephone calls. The students added Electro-Luminescence wire to an old glove in order to give it a "futuristic" look and to simulate the cooling and heating elements. They also added an LED to the index finger with a switch accessible to the thumb. Finally they added the components of an old headset so that the small finger contained the microphone and the thumb contained a speaker. They used this to make and receive calls during their demonstration.

Fig. 4. Making the "EyeGlove" (left) with glued on Electro-Luminescence wire and audio cable to attach to phone for calls. Final prototype (right).

The "EyeGlove" team also developed a prototype home automation system that activated one of three LEDs based on entries on a public Google Calendar. These three LEDs were to simulate three possible devices at home, a light, a cooker and heating. This used a PHP to parse the Google Calendar feed and execute the appropriate Python command to turn on the correct LED. As it was using a Google Calendar, it could in theory be used from anywhere.

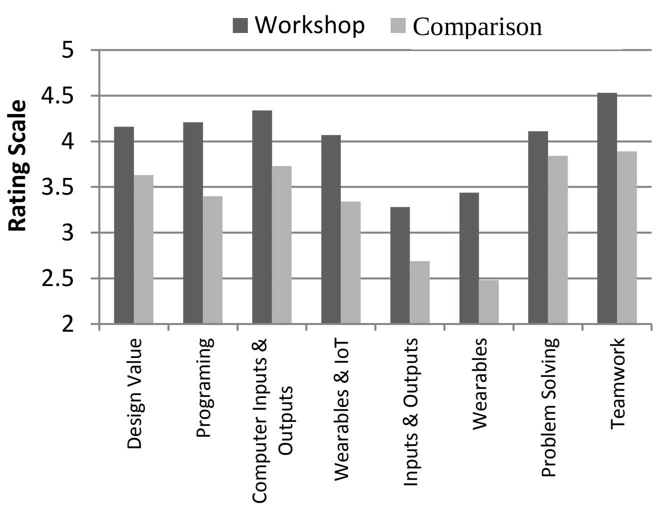

Fig. 5. The difference between workshop and comparison group on the sub-scales of the developed instrument.

B. Comparison Versus Workshop Group

Data collected prior to the workshop revealed that the workshop group scored significantly higher on all of the sub-scales of the instrument apart from the problem solving scale. Independent sample t tests were undertaken on the 8 pre-workshop questionnaire sub scales to establish any differences that existed between the hackathon and comparison groups pre participation. These results indicated that the comparison and the workshop group were not similar on several scales and that the workshop group showed higher levels of motivation in Design, programming, inputs and outputs and Wearables/IOT. They also had higher levels of self-efficacy with Inputs and Outputs, and Wearables/IOT. They also scored their teamwork skills higher than the comparison group. (Fig. 5).

C. Pre and Post Workshop Comparison

The comparison group did not complete the time 2 data collection and therefore are not included in the following section.

TABLE I
PAIRED-SAMPLE T-TESTS FOR THE WORKSHOP GROUP

	M_Pre	M_Post	t	*p*-Value
Motivation				
Design Value	4.2	4.3	-3.63	0.002
Programing	4.18	4.52	-2.319	0.032
Inputs & Outputs	4.38	4.72	-3.327	0.004
Wearables & IoT	4.11	4.47	-2.348	0.03
Self-Efficacy				
Inputs & Outputs	3.35	4.23	-4.574	0.001
Wearables & IoT	3.48	4.48	-5.257	0.001
Problem Solving	4.11	4.54	-2.941	0.008
Teamwork	4.48	4.76	-3.317	0.004

1) Pre and Post Questionnaire Comparison

Paired sample t-tests were performed for the 8 sub-scales of the Significant pre-post increases were observed in all 8 scales (Table I). Fig. 6 depicts increases in all four motivation subscales, following participation in the workshop, indicating that students showed significant increases in their motivation to learn about design, programming, inputs and outputs and Wearables/IOT.

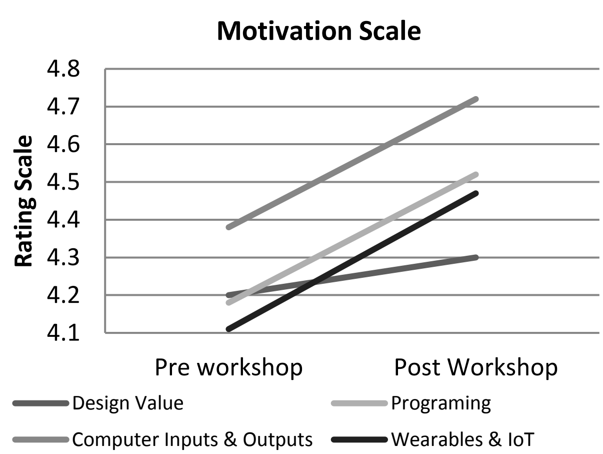

Fig. 6. Shows the differences between the pre and post responses for the four motivation subscales for the workshop group.

Fig. 7 shows the significant increases in the scales which measure self-efficacy. These show that students were more confident in their ability to use Inputs and Outputs and Wearable/IoT after completing the workshop. Fig. 8 shows the significant increases in the problem solving and teamwork scales following participation in the workshop. This indicates that students perceived that their problem solving ability and teamwork skills had improved following participation in the workshop.

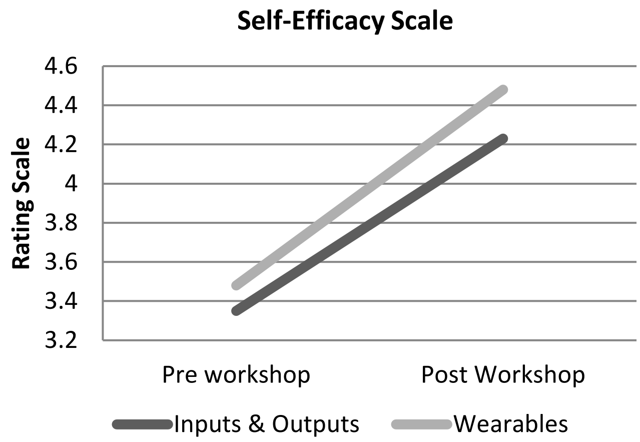

Fig. 7. Shows the differences between the pre and post responses for the two self-efficacy subscales for the workshop group.

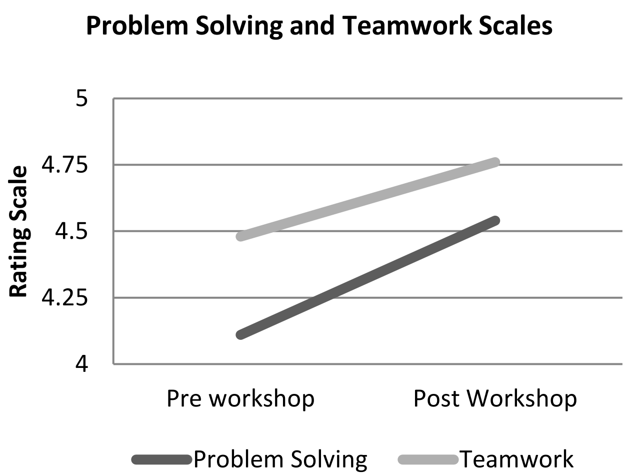

Fig. 8. Shows the differences between the pre and post responses for the problem solving and teamwork scales for the workshop group.

2) *Word association*

Following participation in the workshop there was a change in the words that students associated with computers. Students listed words at time two that were related to the hackathon content, a trend that was not observed at time one. When students were asked to list the 5 words they associate with computers before participating in the workshop and then after, there was a trend towards students associating computers with practical skills and technologies that they used during the week. For example, prior to the workshop the highest percentage of students associated computers with the Internet but this changed following participation where terms such as programming, python and Raspberry Pi featured much more prominently (Fig. 9). “Work” also appears more frequently in the post questionnaire.

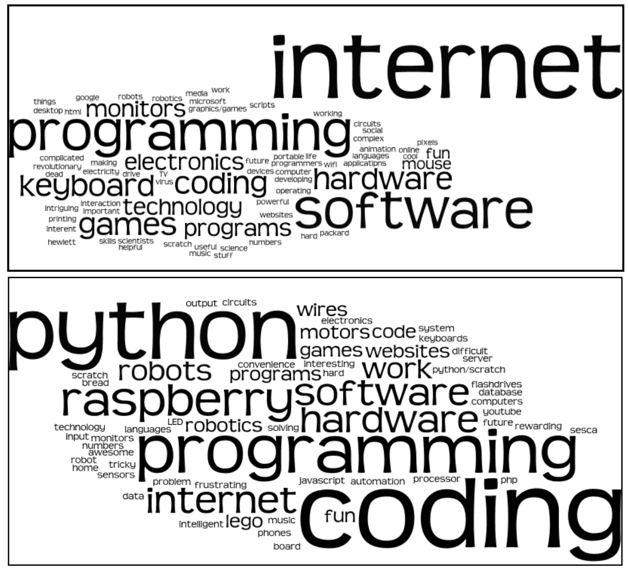

Fig. 9. Pre (top) and Post (bottom) words students associated with computing

When students were asked to list 5 words they associated with careers in computer science before and after participating in the workshop there were changes in word content and type. Before the workshop, *money* had the highest percentage of associations with computer science careers. Following participation *engineering* was most associated with these careers suggesting that participation in the workshop changed students’ views towards the practical content of these careers. Interestingly *challenging* and *teamwork* appeared quite highly in the post list yet did not feature in the pre list, again reflecting the development of students’ knowledge toward the practicalities of the careers following exposure to the workshop content (Fig. 10).

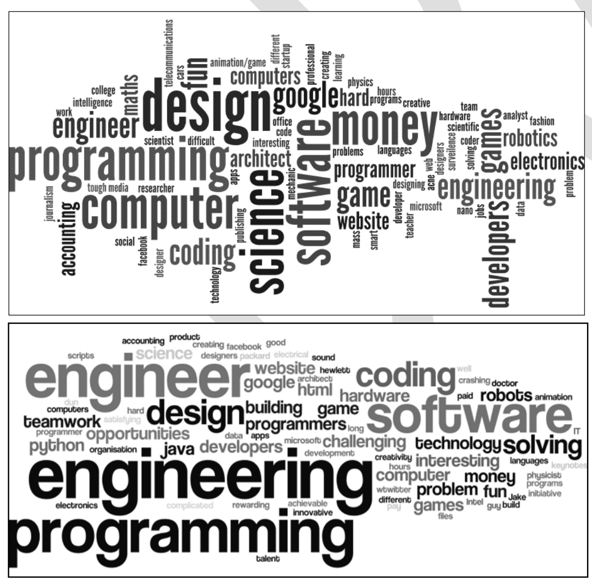

Fig. 10. Pre (top) and Post (bottom) words students associated with careers in computing.

VI. Findings

The pre and post questionnaires demonstrate that the hackathon learning experience did increase the participants’ self-perceived efficacy and motivation in all areas that were measured, this is despite the fact that they already self-reported high scores on the pre questionnaire when compared to the comparison group. Of particular interest is the significant increase in the self-reported self-efficacy in Inputs and Outputs, Wearables and IoT, as these are emerging areas of interest in the field of Computer Science. Combining this quantitative data with the rich prototypes developed by the teams indicate that they have a strong appreciation of these emerging technologies, and how they can be used in practical and meaningful contexts.

Furthermore, the word associations related to computing in general seem to reflect a shift towards practical technologies that might be used in creation of computing artefacts rather than mere consumption.

The word associations of careers in computing also showed a shift to more practical elements associated with the job, such as *engineering*, *coding* and *problem solving* with *money* sliding down the scale in the post responses.

Overall the findings indicate that students received a rich learning experience that enhanced their technical confidence in developing authentic and socially orientated solutions in areas such as Wearable Technology and IoT. In addition they reported increased confidence in 21st century skills such as problem solving and teamwork. Furthermore, their use of language in the post tests would suggest that they have a better idea about the approaches and technologies that may be used in careers in computing.

Further work is needed to explore the “actual” learning that occurred during the study, but the literature does suggest [43] that there is a high correlation between self-perceived learning and acquisition of traditional domain knowledge.

VII. Limitations

The small number of participants is a major limitation of this work. Increased numbers should be pursued but as the workshop is intensive it will be difficult to scale up effectively. The participants also successfully completed an introductory computer science activity before engaging in the hackathon, and were chosen based on their interest and ability to work in teams. This was evident in the high scores in the pre questionnaire versus the comparison group. Altering the selection process or recruiting an unknown cohort, who have not received the same introductory training, may have a significant effect on the overall experience.

The original questionnaires [12, 16, 17] that were used and altered for use in this research used factor analysis for validation. This was not carried out in this research, due to time restrictions, and this may again limit the validity of the findings reported here. Although care was taken to substitute words such as *Design* for *Science*, *Programming* for *Mathematics* and *Wearables/IoT* for *GPS/GIS*, without formal factor analysis there is some uncertainty as to the number of factors at work in the questionnaire.

Based on facilitator feedback and observations, the workshop design might be improved by including mentors with experience in business or marketing. This could enhance the presentations and help refine the quality of the final ‘pitches’. Further enhancements might be to include more examples of code that achieve specific goals. These code snippets may be harvested from previous instances of the workshop, so future participants can build on the work of previous groups.

Integrating this approach to the typical school/classroom would require a number of additional considerations. As this work is focused on educational outreach for the promotion of careers in STEM, it was possible to decrease the student/mentor ratio, dedicate several days to the project and have personnel with the experience and confidence to explore ill-defined technical problems. Using team teaching and mixing subject domain experts (e.g. business studies, graphic design/art, technology etc.) would help reduce student/teacher ratios and provide a rich set of expertise in the class. It would also be possible to subdivide the day long activities so that they could be spread across a number of weeks, although care would be needed in order to maintain momentum.

VIII. Conclusion

There has been work exploring pedagogical and learning outcomes in hackathon-like settings [2, 19, 20], but it has been limited. There is definite need for more work exploring how pedagogical approaches can be used to enhance hackathon learning outcomes. This paper aims to contribute to this area of study by providing a social constructivist model for hackathon design.

The findings suggest that students developed a greater appreciation of the wide range of contexts and applications involved in computer science as a career. In particular the differentiation of roles, that is inherent within our approach, simulates the complexity of real world projects. There are further indications that the use of wearables and IoT technologies provide the students with this richer perspective of computer science applications and in authentic, socially relevant contexts.

The findings indicate that the combination of a hackathon activity and a 21st century learning model makes for an effective experience in motivating and increasing pre-university students’ self-efficacy in areas related to Wearables and IoT. Furthermore the findings suggest that our approach led to a clear shift in students’ conceptions of careers in computing, that may be leveraged or replicated by CS/Engineering educators.

Our structured approach to constructivist learning helped participants further enhance their teamwork and problem solving capabilities. This successful combination of technical and “soft” skills would seem like the ideal learning environment for 21st century learners and promoting careers in STEM.

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