Using Science-fiction Prototyping as a Means to Motivate Learning of STEM Topics and Foreign Languages

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***Abstract*— In this paper we report on the operation and results of a pilot trial on the use of Science-Fiction Prototyping (SFP) as a means to motivate students to engage with STEM and language learning courses. In particular we describe two case studies. The first was conducted in Shijiazhuang University, China, and involved approximately 102 students following a course aimed at improving their English language abilities for computer science applications. The second case study concerned the use of micro science-fiction prototypes, in the form of Twitter-fiction, as a means of motivating pre-university students to take up STEM studies and careers. Finally, the paper concludes by describing future directions of this work**

Keywords; STEM; education; language; technology; innovation; computer-English; science-fiction; micro-fiction; flash-fiction, science-fiction prototypes; buzz-boards

I. INTRODUCTION

It is widely recognized that science, technology engineering and mathematics (STEM) are vital workforce skills for a modern competitive economy [1]. Such skills are imparted to students as part of the educational process. However, many economies are reporting that the education system is failing to enthuse students in sufficient numbers to satisfy the STEM industry needs. In parallel with this need for STEM proficiency, the world is becoming increasingly globalized, with competency in foreign languages becoming increasingly important. For example, for non-English speaking emerging economies, the acquisition of a combination of STEM and English language skills is important. In this paper we examine how a new methodology, Science Fiction Prototyping, has been piloted in China and the UK as a means to both inspire students to study STEM subjects, and to support their learning of English language. In doing this we will describe two case studies, one at Shijiazhuang University in China, the second at the University of Essex in the UK.

II. SCIENCE-FICTION PROTOTYPING

One of the major challenges to intelligent environments and, indeed, all science, technology engineering and mathematics education courses is how to motivate students to study these topics and follow a STEM career. One topic that many engineers and scientists cite as having brought them into STEM is science-fiction, as it connects with the human spirit of adventure and imagination. Moreover, imagination is seen as a key ingredient of engineering design, as it enables designers to think 'outside the box' and create innovative products. Towards these ends a new discipline has been developed and deployed by one of the largest STEM companies in the world, Intel, who are using science-fiction as a both an innovation tool to enable more imaginative (and novel) design, as well as a language that connects their designers to their customers. This is called *Creative-Science* and the methodology is called *Science-Fiction Prototyping* (or *SF-Prototyping*, for short) [2]. In addition, most students arrive at University with the dream of changing the world either by inventing some new product or creating a new business, emulating the inspiring stories of companies such as Microsoft, Google and Intel. This approach plays into those aspirations. Apart from linking to innovative science and engineering design, the methodology also involves the use of a rich (and technical) written and oral vocabulary that is at the heart of language learning.

A. *Science Fiction Prototypes (SFPs)*

In Johnson's book he suggests the use of five steps to create an SFP:

- Selecting the science and building an imaginative world,
- Identifying a scientific inflection point,
- Analyzing the ramifications of the science on people,
- Identifying a human inflection point, and
- Reflecting on what was learnt.

These 5 simple steps are relatively easy for a student to grasp and to begin writing a SFP. A SFP will be typically 2-10 pages in size. To assist students the Creative-Science Foundation (CSf) provides a treasure-trove of resources on its website, include numerous examples of earlier SFPs [3]

B. *Micro-SFPs and Twitter-SFPs*

Twitter- based SFPs are just 140 characters or less (the size of a Twitter message) which equates to about 25 words (in English). Generally a Twitter-SFP will focus on some technology (eg machine, gadget, etc) which includes an action to illustrate its use, plus actors (eg a person) framed in a simple (if partial) narrative, as in any story. Writing such short fiction requires skill and the general advice is to start by (1) identifying the technology, then (2) by creating a plot. A good

approach is to start big, then reduce it to less than 140 character [4]. A cellphone text message is 160 characters in length, and so these micro fictions can be communicated by twitter or SMS, adding to the sense of fun and social interaction, which helps with motivation.

III. COMPUTER ENGLISH

In China, it's mandatory that Universities include a module that teaches "Public English", as this is seen as an essential skill for creating successful scientists, and engineers to drive the Chinese economy forward. After the 'Public English' course, a specialized English module called 'Computer English' is also taught mandatorily, in Chinese computer science departments, which is specially designed for the students in the 3rd or 4th year (a few in the 2nd year) in all Chinese universities [5]. It is considered to be an important course for students to enable them to understand and absorb advanced computer technology in English [6]. This course combines specialist English language vocabulary for computer technologies with 'Public English', aiming to impart knowledge of professional English vocabulary and expressions, to improve the student's capabilities for English reading and writing as applied to computer science [7]. While the aims are laudable, in the eyes of students the process can sometimes prove somewhat tedious and boring, with students lacking motivation.

The popular teaching method for this type of course in China is for teachers to guide students in the reading and translation of professional English articles into Chinese. Most often such courses follow a book, which focuses on learning professional English vocabulary and expressions via reading and translation, rather than through co-developing technology skills which we advocate in this paper.

Having taught such a course for many years it struck us that English could be taught in a more effective and interesting way, if it is set into an engaging and motivating context. From our use of SFP with practicing scientist and engineers to support product innovation, it became clear that SFP had the potential to both motivate people and exercise language. Thus, we decided to explore the use of SFP for teaching Computer English classes and to investigate its use as a vehicle for motivating pre-university students to follow a STEM pathway. In the following sections we provide an overview of two case studies that explored this proposition

IV. CASE STUDIES

A. *Computer English case study at Shijiazhuang University*

One hundred and two students attended the Computer English class at Shijiazhuang University in the autumn term of 2013. They were divided into 17 groups of 6 people (based on their dormitory). Each group was tasked to design a science fiction product using the creative science approach, based on computer technology, and using English vocabulary to describe the product and how it might influence human life in the future. Ten supporting lectures were provided and the groups were required to engage with each other (and the teacher) via written and orals communications, culminating in producing a small SFP of a few pages in size, together with a group presentation. Summarized examples of some of their work are shown in the following sections.

1) *The projection pen*

The projection pen was inspired by the concept of 3D, wireless sensors. The students envisaged that it would look and works like an ordinary pen (e.g. it could be used to write and draw) but it also functioned like a portable I/O device such as virtual keyboard and screen, connecting with smart phones and tablets etc (see Fig.1). They envisaged that the projection pen had several functions, for example, it could provide an external infrared virtual keyboard or be used as a portable projector to view maps, pictures or watch movies etc They went some way to considering the performance specification, such as the need for low power consumption etc.

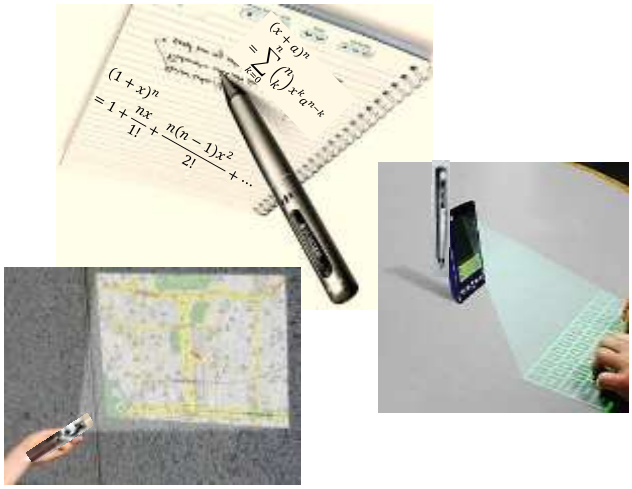

Figure 1. the multiple function of a projection pen

2) *The cake printer*

With the rapid development of 3D printer technology, inspired the students to propose a cake printer, as shown in Fig.2.

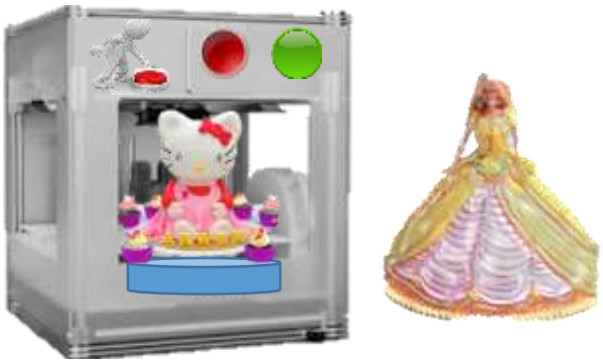

Figure 2. the structure and operation procedure of the cake printer

The students envisaged that using their printer, a variety of cakes could be made by users pressing some buttons to choose their favorite type of cake, personalizing it with special ingredients or patterns. Although there is not sufficient space to provide much detail here, they researched the kind of technologies that may be involved but clearly, being a work of science fiction, they were allowed to stop at this conceptual view.

3) The portable and intelligent washing machine

In this SFP the students were motivated to solve some of the problems they were encountering when using traditional machines to wash their clothes. They said that traditional washing machines were heavy, stayed in a fixed place and required users to manually insert washing powder. They wanted to be able to share the machine or take it on a family holiday and proposed a luggage-like or foldable version for travelling or home space saving as shown in Fig.3. They suggested the washing machine could be made using retractable plastic with a separable nanometer barrel that featured embedded sensors and special material for dirt and oil stain cleaning. Hence it needed to sense the condition of the clothes and configure an appropriate program. In addition they had an idea for using dirt and oil adsorbing technology rather than detergents.

a. luggage-like washing machine b. foldable washing machine

Figure 3. the portable and compressible washing machine

The above are summaries of 3 of the 17 student groups' work. Other topics included an intelligent household, Internet contact lenses, plastics-based technology, roach trapper etc. The following paragraph is selected from students' presentation to illustrate their feeling towards the methodology and their competency at English.

Extract from group 17:

"*This study we collected from the Internet and library, someone is responsible for the theory, someone responsible for gathering example. Everyone is responsible for different things. In this task, we all play a role, everyone played their strengths. Through this task, we have more of the team cooperation spirit, we also more profound learning computer English. Our team because of the cooperation more unity. The understanding of English and computer are deepened layer. Thanks for the tasks to make our team and grow. Hope we have more opportunities to participate in such a task. Strengthen the English communication, strengthen the computer knowledge, and strengthen the teamwork cooperation.*"

Of course their main outputs were science fiction prototypes which comprise many pages in themselves. We are not reproducing these here but one example is published in the workshops of this conference [11] In conclusion, although the students science fiction product ideas s are not novel and contain errors in their grammar and English expression, the main purpose of the exercise was not to generate innovative products (although that was what motivated the students) but rather to exercise their English language communications skills, an aspect that this scheme enabled most effectively.

B. New Creatives workshop at Essex University

Figure 4. Anasol Pena-Rios, demonstrating a SFP generated product to the K12 students.

The 'New Creatives', was a pilot study, conducted in the winter term of 2014 at Essex University, to explore the potential of SFP to motivate pre-University students to study STEM subjects. It involved k12 students writing a set of micro-SFPs in the form of Twitter-SFPs (140 character / 25 word stories) conveying their views about the possibilities for future technologies.

The event was organized as a daylong series of 3x 80 minute workshops attended by over sixty 15-16 year old students from two Essex schools, Thurstable School and The Colne School. Thirty Four micro-fictions were written which can be viewed online [8]. Each 80 minute workshop was structured as; 30 minutes for introducing the principles of SFP and Twitter-fiction (including an Intel video) [9], 20 minutes for a motivational demonstration (see figure 4) and 30 minutes for creating the Twitter-SFP. To create the SFP, the students were assembled into groups of around 5 students and asked to spend 10 minutes brainstorming on a future product innovation and a further 20 minutes writing the micro-fiction. Thirty four micro-fictions were created, the following are 3 examples:

- Physics (90 characters) – "*I'll just pop off to get some sushi. Bob established a wormhole link to Japan and vanished.*"
- 3D-Printing (117 characters) – "*OMG where did u get ur coat from? It was the only one left in the store. But I can duplicate it 4 u. Thank u so much.*"
- Embedded-Computing (126 characters) – "*Amy can't diet but her bracelet helps stop her eating*

naughty treats over a salad. It clamps tight on her wrist & shocks her!"

Other Examples can be seen on the Twitter-SFD site [10] together with information on writing these short Twitter-SFP is on the Creative-Science website [8]

V. Refections & Future Directions

Both pilot studies ran smoothly and were positively received by the students. The Shijiazhuang study was complex in that it ran for a term (some 10 sessions) and involved teaching both English language and computing. While this study didn't involve gathering quantitative data we have feedback from the teacher who gave both the non-SFP and SFP versions of the course. Her findings were that the method resulted in a dramatic reduction in absenteeism and a significant increase in the average marks. This improvement was attributed to the students being better motivated and experiencing enhanced engagement with the course, which was particularly important for exercising the language components. In connection with the Twitter-fictions, it is too early to know how successful these were in increasing the number of students choosing STEM subjects but, again, the feedback from the directors of the workshops was encouraging. All the student groups handed in a Twitter SFPs which, given they had only 30 minutes to generate a product idea and an associated micro-fiction was a remarkable achievement. A barrier to applying SFP in schools has always been the lack of time to write a multi-page story, which takes many hours, if not days. In that respect, this trial proved that Twitter-sized fiction can overcome this obstacle by providing a procedure that can deliver outputs within the time limits of typical school lessons. Moreover, the Twitter and Text fictions have potential to connect with youth culture and the need for Micro-SFPs to convey ideas concisely has proven especially useful as a tool for developing good language skills.

Figure 5 –A $35 robot constructed from FortiTo's BuzzBoard rapid prototyping kit

In terms of the future we are working in a number of directions. First, we aim to refine the procedures and materials for both the 'Computer English' and Twitter-SFPs. For example, we are writing a book (to be published by the Tsinghai University Press) that will provide support for 'Computer English' courses. In addition we hope to offer an option whereby we incorporate a "rapid prototyping toolkit" (see figure 5) that enables students to build some of the products they innovate, thereby supporting the computing element of the course by better marrying it with the language components offered by the SFP. The *buzz-board* toolkit is an open-system comprising some 30 pluggable hardware boards that can be interconnected together to make a variety of "*Internet-of-Things*" applications (see www.fortito.com). Concerning the Twitter-fictions our aim is to provide better online support for the twitter activities, moving towards the use of augmented reality.

VI. Summary

In summary, this short paper has introduced the use of SFP as a means to motivate students to study STEM topics and language learning. The work is at an early stage but we aim to move it forward over the coming years through improving and expanding the set of supporting tools including books an augmented reality eBook based system. Finally we hope that this work will inspire others to apply SFP to teaching computers and we invite any readers interested in applying these to teaching other languages to contact us.

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