

An Online Game-based Learning System for STEM Knowledge and Role Models - The Masters of STEM Project

Lachlan Mackinnon^{1,2}, Olaf Hallan Graven² & Liz Bacon¹

¹University of Greenwich, Old Royal Naval College, London, UK

²Buskerud and Vestfold University College, Norway

l.mackinnon@gre.ac.uk

Lachlan.MacKinnon@hbv.no

Olaf.Hallan.Graven@hbv.no

e.bacon@gre.ac.uk

Abstract

The Masters of STEM project seeks to excite young people about the positive impact of STEM (Science, Technology, Engineering & Mathematics) research and innovation, both throughout history and in the current day, and to introduce and reinforce positive role models from the STEM community. The purpose is to promote broader knowledge of STEM and the impact it has had on society, and to encourage more young people to undertake higher education and follow careers in STEM. The project already has partners in Europe, USA and Brazil, and continues to grow the partnership and funding base.

At the core of the project is the development and deployment of an online game platform, supporting users playing short game scenarios developed by the project, and allowing them to develop their own scenarios utilising characters developed by the project to represent the role models we identify, the Masters of STEM. The game platform will support multi-lingual versioning, and role models will be identified and characterised for the scenarios at both global and local level. Rules and constraints will be applied at character level to ensure the scenarios developed by users are within acceptable limits of behaviour and activity. A number of types of scenarios will be developed, offering interest and engagement for users of all ages, from infant to adult, and this will permit the development of a user community generating their own content for the platform.

The project will disseminate these outcomes widely throughout the world, particularly through the schools networks. To achieve this, websites will be developed by the project partners providing localised information on STEM activities, careers and opportunities in different regions. This will permit the development of region-specific linguistic and cultural representation of information, and identification of role models, both real and media-generated. Information on these role models will feed through to the game platform, which will be linked to these websites to provide both general and region-specific scenarios. The project partners will also use online surveys to capture information on young peoples attitudes towards STEM, positive views on characters from the STEM community, and interest in games.

Initial work on the games platform has already begun, based on the Unity games engine and existing work on the scenario-authoring tool from the Pandora+ platform. Contact has been established with a number of media groups to ascertain the potential to use media characters as STEM role models, e.g. Big Bang Theory & CSI characters, and, where possible, real individuals will be approached to give their permission for their images and stories to be used in the system. Historical characters should not require such permissions, but the project will ensure that all characters are treated with respect, and the system will not permit inappropriate scenarios to be generated. User evaluation of the system will be sought continuously through feedback surveys, frequency of use measures, and user ratings. Impact measures will be established by agreement with the wider community.

1. Introduction

The problems of recruiting young people into STEM education and careers have been well documented over the last few years (Bacon et al, 2008), and the EU currently has a number of initiatives, such as the e-skills and e-competences frameworks (e-CF, 2014), specifically aimed at

developing STEM professionals to fill existing and predicted gaps in the workforce. The importance of this cannot be over-estimated, current predictions foresee a shortage of skilled professionals in the EU IT workforce, particularly in specialist areas such as cybersecurity, of at least 1 million by 2020. Unfortunately, STEM educational subjects, which are traditionally seen as *hard*, have seen significant declines in popularity amongst school pupils, with many of them studying *soft* subjects in which it is perceived to be easier to achieve higher grades. This has had a knock-on effect on University and College populations, with STEM degree subjects seeing a significant decline in student numbers over the last decade (Bacon et al, 2008). This picture has not been universally true across the EU, with member states in the East, in particular, having stronger recruitment to STEM subjects, but those states are now beginning to experience similar problems to those experienced by their western neighbours (European Job Outlook, 2014). Unfortunately, this problem has arisen at a time when the global competitiveness of the EU is fundamentally founded in the growth of the *knowledge economy* and our ability to compete in *high-end* industries, requiring highly skilled personnel predominantly in STEM subjects. The cost-base of EU industries, in comparison with the costs in developing and emerging economies, mean that there is no potential to compete in *low-end* manufacturing and production industries, where the skills and knowledge requirements on the workforce are far lower.

2. Attracting Young People to STEM Studies/Careers

Many of the subjects that young people are currently drawn to study are based on popular cultural perceptions, promoted through mass media, so while many young people aspire to emulate their sporting or musical heroes, there are also many who seek to emulate roles or role models based on popular characters from film/TV. Examples include the global growth in applications to study forensic science, based on the popular CSI TV series (CSI, 2015), and astro-physics/physics, based on the popular Big Bang Theory series (Big Bang Theory, 2015). Similar phenomena have been experienced locally, within countries, based on popular local series and characters. Whilst it might be argued that such role model emulation is a poor basis on which to base a career, and that once these young people have matured they will determine a different path, the evidence suggests that for many students these early influences do determine their long-term career path, and any positive impact that can be generated to encourage STEM careers should be actively embraced.

This is not to suggest that there has been no work carried out to encourage young people to follow STEM education and careers, or that such work as has been carried out has been unsuccessful. Considerable effort and resources have been invested in every country in the EU to encourage young people into STEM careers, with glossy publications being provided into schools through the careers service on all aspects of STEM from employers, STEM learned societies, public bodies and government. Websites have been created with useful and well-produced information, career descriptions and specifications, video and text biographies of real people in STEM careers, and famous STEM leaders from the past, such as Big Ambition (e-skills UK, 2013). Projects have been funded to specifically target young people to engage with particular subjects, CS4Fun (<http://www.cs4fn.org>), TechFutureGirls (<http://www.techfuturegirls.com>), TeenTech (<http://www.teentech.com>), Scratch Day (<http://day.scratch.mit.edu>), Webloz (<http://www.webloz.net>), Microsoft Imagine Cup (<http://www.imaginecup.com>), and many more, and all of these have had a measure of success in attracting young people to consider STEM careers. However, there is a need to find a larger-scale and more impactful approach that can link in to all of these existing facilities and resources, and bring larger numbers of young people to investigate them and potentially take-up a STEM education and career. In fact, it can reasonably be argued that the real issue is not the quality of the resources being provided, but rather finding a route to engage with young people that has the level of impact achieved through the major film/TV characters and series, and can be linked directly to these existing high-quality resources to encourage them to consider STEM careers. So, obviously, one route to consider would be the creation of a film or TV series that showcased a group of young people engaged in STEM careers in interesting and humorous vignettes demonstrating their knowledge and skills, or a group of dedicated STEM professionals carrying out important work with significant social consequences on a daily basis, or a series of bio-pics of famous STEM role models of the past, showcasing their contributions to knowledge and impact on society, or.....?? The problem with this approach is that, as the film/TV industry professionals will tell you, there is no way of knowing whether or not a film or TV idea will have popular appeal, and even of

those that the industry does decide to produce only a small percentage become significantly popular – hence there are so many sequels of successful films and TV series.

If the cost and risk of investing in film/TV is too prohibitive to consider for this problem, then what other routes exist that could provide access to engage a high proportion of young people and be linked in to the existing resources and networks? Given the proliferation of digital technology, and the fact that we would anticipate that to be successful in STEM education and careers we need our young people to be tech-savvy, two obvious routes would be social media and computer games.

There are already lots of social media feeds out there, and most of the initiatives described earlier to encourage young people to consider STEM careers also have social media feeds, but the key issue for social media is the need to create an external source around which social media activity can be generated. In terms of the film/TV discussion above, there are a large number of social media feeds and groups associated with the CSI series and characters (2015) and the Big Bang Theory series likewise (2015). These groups spend considerable time and energy discussing their favourite characters and plot elements, driven by the arrival of new episodes and characters through the lifetime of the series and often heightened by inputs from the actors and crew working on the series. However, with the exception of “flash-mobs” there are very few events or phenomena that are generated entirely from within social media, and it is therefore better to see social media as a means of dissemination, proliferation, discussion and response.

Computer games, on the other hand, have a far greater level of interactivity amongst the user community, and more levels of engagement than most other forms of media. The rather stereotyped view of games players as young men shut away in their bedrooms, playing *shoot-em-ups* on their own, has been overtaken by the range and proliferation of games, and game-players, in recent years. Massive multi-player games, whether role-playing or otherwise, have taken a significant share of the market, and now as much time, if not more, is spent in chat rooms discussing the game as in actually playing it, e.g. World of Warcraft (<https://eu.battle.net>). Reality and purposeful games have become extremely popular with both female players and younger players, e.g. FarmVille (<https://zynga.com/games/farmville>), The SIMS (<http://www.thesims.com>). Complex mystery and puzzle games have grown in popularity amongst older players, whilst brain-training games have brought in a population of elderly gamers. Games are also now available on the majority of possible digital platforms, so while many young people still play on dedicated platforms, e.g. Xbox One (<http://www.xbox.com>), PS4 (<https://www.playstation.com>), they are also playing on Smart TVs, mobile phones, tablets, and potentially on any screen-based digital device you can think of. Importantly, for the age demographic we are focused on in this call, a study by Roy Morgan (2014) of young Australians showed that they are now spending more time using digital devices than watching TV. Therefore, the argument must be that, if we can provide them with role models and interesting activities associated with STEM careers on their digital devices, and link this to the significant range of resources and activities that already exists, we should be able to encourage many more young people to consider a career in STEM.

Development of Computer Games is subject to the same caveats as the production of film/TV series, and with the development cost of a full-scale platform game running at around \$20 million over 2 years, the level of investment and risk is prohibitive. However, the games community has developed its own solution to these cost issues preventing user involvement in games development. There are so-called *indie games*, which are low-cost independent games developed by small companies/solo developers, these tend to be more limited in scale but are often more innovative in ideas. Many large-scale games have developed user configuration and development capabilities for their players, to encourage their continued and greater involvement in the game, ranging from character creation to level-editing, e.g. Doom (<http://www.doom.com>), Quake (<http://www.quakelive.com>). Most importantly, this encouragement from the games community, combined with the growth of devices and in particular the advent of the Apple App-Store and Android Marketplace, have led to a proliferation of *user-generated content*, with many popular press stories of young people making large sums of money or developing their own companies by this route, e.g. Flappy Bird (<http://www.flappybird.io>). This has, in turn, led to the development of games platforms based around community generation and support, such as STEAM (<http://www.store.steampowered.com>)

and *user-generated content*, such as Minecraft (<https://www.minecraft.net>), targeted to young and novice players as well as the more experienced. Games produced through these routes tend to be short and relatively simple, lacking the complexity, extended narrative, characterisation and visual graphics of the large production games, but they are nonetheless popular, widely-played and low cost, both to produce and to play. This route to development also means that novel ideas or narratives can first be developed and tried out through a low-cost route within the community, and those that prove most successful can then be subject to further development or full-scale production. Clearly, this also results in large numbers of these short games being produced, of variable quality and content, which are then ranked for popularity within the community by the simple measure of number of plays, but even games with small numbers of plays have an audience and an impact.

3. The “Masters of STEM” Project

In considering how to address the issues identified in the previous section, the target of encouraging more young people to consider careers in STEM by exposing them to high-quality innovative online learning resources, information resources, examples and role models is one that has seen considerable investment in member states in recent years. As we have argued above, the need is to engage young people where they are spending the bulk of their time, and having obtained their interest, to then introduce them to the range of educational and informative resources that might then encourage them to follow an education and career in STEM. We believe that one route that offers considerable potential to be successful in achieving these goals is through the development of a player community in the online *user-generated content* games sphere, which we can link in to the existing STEM online learning materials and resources, locally, nationally, across the EU and worldwide. To achieve this we propose the “Masters of STEM” project.

The key concept of the “Masters of STEM” project is the use of computer games to engage young people in consideration of the issues and social context of STEM, the use of STEM in both historical and modern contexts to advance society, and to introduce role models, both real and media-generated, which could, as a result, lead to them in following a STEM education and career. We know from existing research, particularly in games-based learning, that games are immersive and engaging, encourage reuse and, as a result, if properly-designed can have positive learning impacts (Graven & MacKinnon, 2010). However, the costs and time of developing specialist, bespoke games to address these issues would be prohibitive, so, as identified above, a further key to this project is the development of a games platform to allow user-generated content to be created, disseminated and played, that is realisable and cost-effective within the bounds of this call.

Although there are existing games communities and user-generated content models in the marketplace, as identified above, there is nothing that currently offers the functionality or the structure that we propose, and there is certainly nothing like this relative to the STEM education and careers issues. We can therefore reasonably argue that this project represents a contribution to the current state-of-the-art in educational games technology, and, while the technologies developed and applied will be within the current marketplace, the methodology and approach will also represent a contribution to the state-of-the-art.

From a player perspective, Masters of STEM will allow them to develop a digital narrative for their game, and to identify the characters they wish to be engaged in that narrative, they will also be able to choose an environment in which the action takes place, from a limited list, and they will have a fixed number of scenes they can describe within the timeline of the narrative. The narrative will then be loaded onto the game platform, realised as a game, and accessible for play through a web browser or web-enabled app. This approach will lend itself to tutors using games with students to introduce the key activities that important figures in the history of STEM undertook, to set those out as a game for their students, and then to consider the impact and implications of those activities. Players will be able to configure characters in a variety of narratives, subject to constraints imposed on those characters to ensure they cannot be used inappropriately.

One key argument in this approach is that users will not require specialist knowledge of the technologies involved to either play or create a game, or to configure and introduce a character, and

that maintenance and support of the platform will be low cost and non-resource intensive. Having said this, user configuration of the system by more advanced players, to introduce games of greater complexity, will be enabled within the platform, subject to verifiable player registration and accountability. In the longer term, additional levels might be introduced within the platform, to differentiate content and audience, but that is beyond the scope of the first version.

The project is currently producing a toolset to support the creation and loading of the digital narrative and characters, based on a scenario authoring tool developed for the Pandora+ training environment (<http://pandora-plus.gre.ac.uk>), and the games platform is based on the existing Unity games engine (<https://unity3d.com>). The game platform will support multi-lingual versioning, and role models will be identified and characterised for the scenarios at both global and local level. Rules and constraints will be applied at character level to ensure the scenarios developed by users are within acceptable limits of behaviour and activity. A number of types of scenarios will be developed, offering interest and engagement for users of all ages, from infant to adult, and this will permit the development of a user community generating their own content for the platform.



Figure 1: Example of popular character (Batman) representation in games – Minecraft & Lego

The partners in the project will generate a number of characters and scenarios to provide initial catalogues, and they will engage with networks and disseminate information about the project throughout the world, particularly through schools, to encourage take-up, use, and the generation of new scenarios and characters. To achieve this, websites will be developed by the project partners providing localised information on STEM activities, careers and opportunities in different regions. This will permit the development of region-specific linguistic and cultural representation of information, and identification of role models, both real and media-generated. Information on these role models will feed through to the game platform, which will be linked to these websites to provide both general and region-specific scenarios. The project partners will also use online surveys to capture information on young peoples attitudes towards STEM, positive views on characters from the STEM community, and interest in games.

4. Current Status and Future Development

This is not intended to be a commercial product, as it is seeking to address an important societal and industrial need across the EU, and widespread take-up and use is more important than any commercial incentive, which might inhibit that use. The project will seek to engage with STEM industrial representatives, membership bodies and learned societies, educational bodies, and government bodies to investigate hosting and ongoing maintenance support for the Masters of STEM games platform and associated architecture, once the project is complete. If the project is at all successful in its objectives, we believe there will be a considerable appetite amongst these groups to host and maintain, especially since the project is focused on low cost, and the outcomes will meet

objectives for all of these groups. Given that the problem of encouraging young people to consider education and careers in STEM is not limited to the EU, the project is seeking to establish international contacts to support and share best practice and resources in this area. We already have support from the George Lucas Foundation in the USA, and the games academics at the Universidad Catolica do Sao Paulo in Brazil, and we are seeking permission from CBS for use of the characters from Big Bang Theory and from CSI within our character catalogue. Our intention is not to make the project completely open-source as this might lead to undesirable consequences if games generation is uncontrolled, and would certainly present problems in gaining authorisation for the use of proprietary or living characters. Accordingly, since this not intended to be a commercial exploitation, the project will investigate the creation of not-for-profit charitable foundation, preferably with representation from the groups identified earlier, to oversee the ongoing development and maintenance of the Masters of STEM system.

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