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Work in Progress: Starfish Schoolhouse: Development of a Story Based E-Learning Module to Teach Regenerative Medicine Concepts to Middle and High School Students and Teachers

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Dr. Cheryl A. Bodnar is an assistant professor in the Department of Chemical and Petroleum Engineering. Previously, she has worked as an educational training manager with the University Health Network in Toronto, Ontario Canada. In this role she had the opportunity to create summer training program activities for undergraduate students, scientific and professional development workshops for graduate students and post-doctoral fellows as well as coordinate a variety of public and K-12 outreach initiatives. In addition, she obtained her certification as a Training and Development Professional (CTDP) from the Canadian Society for Training and Development (CSTD) providing her with a solid background in instructional design, facilitation and evaluation. Dr. Bodnar's research interests relate to the incorporation of active learning techniques in undergraduate classes (problem-based learning, games and simulations, etc.) as well as integration of innovation and entrepreneurship into the Chemical and Petroleum Engineering curriculum. In addition, she is actively engaged in the development of a variety of informal science education approaches with the goal of exciting and teaching K-12 students about regenerative medicine and its potential.

Ms. Joan Frances Schanck, Pittsburgh Tissue Engineering Initiative, Inc.

Joan F. Schanck is the director Education and Workforce Development at Pittsburgh Tissue Engineering Initiative. Schanck joined the Pittsburgh Tissue Engineering Initiative in June 2001. Her work is focused on providing high quality educational programming within the field of tissue engineering and regenerative medicine science as well as to increase awareness of Pittsburgh's leadership role within this promising field of biomedicine. A native of Pittsburgh, Penn., Schanck's professional background includes over eighteen years of specialized experience in administration, education, research, fund raising, collaborative team building, program development and direct care/services delivery within the university, community and non-profit, public health, and education settings. Schanck was educated at the University of Pittsburgh, graduating with a bachelor of arts, concentrated on Psychology and Legal studies, and a master's of Public Administration with graduate certificates in non-profit management, educational leadership, and policy analysis, focused on public health and public education policy. Throughout her career, Schanck recognized the importance of education and the need to develop collaborative, multidisciplinary education and research training across formal and informal educational environments. In her role as director, she has developed and implemented novel, interdisciplinary educational opportunities. Resultant programming spans the levels of learning to include undergraduate, graduate and post-doctoral training along with formal and informal educational experiences and programs for the general public, K-12 students and teachers. Schanck has successfully straddled the worlds of cutting-edge, biomedical research and education, maintaining a focus on the importance of participation in interdisciplinary science and research training for a community of learners with the goal to positively contribute to the growth of tomorrow's trained teams of engineers, materials and life scientists and clinicians working collaboratively within the fields of tissue and regenerative medicine. Since joining PTEI in June 2001, she led and developed PTEI's educational portfolio expanding from sets of regionally based programming toward national, multi-institutional training and educational iniatives to include: multi-institutional pre- and post- doctoral training programs in partnership with the Armed Forces Institute for Surgical Research (AFIRM) consortium, and the Advanced Regenerative Medicine (ARM) program Phases III-V; Summer Undergraduate Research Programs (NSF and NIH); Postdoctoral Fellowship Program; Research Experiences for Teachers (FIPSE); Adventures in Biotechnology for HS Students (PADCED); Summer High School Research Program, K-12 TE and Biotech education and curricula development; 2+2+2 Life Sciences Pipeline (FIPSE and PADCED); Middle and High School Summer Camps for disadvantaged students; SEPAand a host of other formal and informal educational activities including a Phase I and Phase II SEPA project featuring a permanent science center exhibit, travel component (7 sites across US,

with videos within Scotland Stem Cell Center Exhibit and translation into Spanish) and teacher professional development and curricula materials. Since 2001, Ms. Schanck has been involved in direction of all PTEI educational programs. Professional background includes 18 years of specialized experience in administration, education, research, fund raising, program development, and direct care/services delivery within university, community and non-profit, and education settings. She has participated in the development and implementation of community educational programs serving minority and "at risk" youth and women through local MH/MR Community Services, Manchester Craftsman Guild, Angora Gardens, Women's Health Services, Allegheny Reproductive Center, and Pittsburgh AIDS Task Force, and is an active member of the Allegheny County Workforce Diversity Committee. Within PTEI, her efforts focus on the leadership, development, planning, coordination, and implementation of PTEI's complete suite of educational programs.

Dr. Kalyani Raghavan, LRDC, University of Pittsburgh
Mr. Nathan Grant Smith, OpenArc LLC

Over the past eighteen years, Nate has led marketing and brand management for organizations including international non-profits, communications firms and technology start-ups. Smith's professional expertise includes, strategy and tactics to build brands for colleges and universities, technology ventures, healthcare, cultural institutions, foundations and non-profits. Mr. Smith is a devoted husband and father. Time at home is with his wife, two children and the family dog. He is a foodie, backyard sports hero, and basement rock-star.

Mr. Kurt Hess, Kurt Hess Illustration & Information Design

Kurt Hess is an illustrator and Information designer with 20 years experience.

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Robert Melvin has over 20 years of successful and wide-ranging experience writing for publication, working both independently and with agencies and organizations.

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Abstract: Regenerative medicine's potential to revolutionize today's health care treatments offers great promise as a cutting-edge, multidisciplinary field to excite the next generation of scientists and engineers. Unfortunately, many of the noteworthy websites on regenerative medicine have been assembled utilizing a traditional textbook style format. In spite of amazing scientific images, pictures and graphics with accurate and informative text, such sites often come across as less appealing to the middle and high school audience (grades 7-12). In an effort to inspire and inform middle and high school students about this dynamic field, we have created the *Starfish Schoolhouse* through supplemental funding received from the NIH Science Education Partnership Award (Grant# 3R25RR023286-05S1). This web-based platform, hosted as part of the Pittsburgh Tissue Engineering Initiative's (PTEI) "If a Starfish Can Grow a New Arm than Why Can't I?" project featuring interactive, permanent and travelling science center exhibits, classroom curricula and teacher professional development, provides middle and high school students and teachers an immersive, web-based, story-driven approach to learn about regenerative medicine and stem cell research.

The focus of this publication will be on the development of the first story based, e-learning module on stem cells entitled, "Professor Regen and the Nemesis Hunt". The learning objectives for this module were three fold: (1) to allow students to be able to differentiate between the different types of stem cells; (2) have students identify methods used to isolate stem cells; and (3) enable students to be able to identify advantages and disadvantages of the use of each type of stem cell in regenerative medicine practice.

In an effort to make this module satisfy these learning requirements, while also further igniting and retaining the attention of our middle and high school target audience, we partnered with OpenArc, LLC who helped take the scientific content and concept ideas presented and transform them into a suspense-based plot and story-line with engaging characters. The storyline for this first module follows Professor Regen on a hunt around "Anyville" while she tries to locate her missing stem cell lines, later found to be stolen by a former colleague, Dr. Nikos Nemesis. The module consists of seven distinct chapters of which six relay scientific information related to stem cells while assessing students'/teachers' understanding of this material through small, randomized chapter quizzes. In addition, the story-based e-learning module allows students and teachers the flexibility to choose which direction they would like to take the story via the integration of a map where participants select which area of "Anyville" they would like to search for the missing stem cell lines. Upon completion of the e-learning module, participants are presented with a mastery quiz to determine overall comprehension of the material presented.

In partnership with the Learning Research and Development Center (LRDC), the first module will be piloted in the winter of 2013 with middle and high school teachers and students for its ease of use and ability to engage, inspire and inform the target audience about stem cells.

Introduction

Regenerative medicine is currently a hot topic in the biomedical field. It is envisioned that technologies developed within this field will have the potential to revolutionize medicine as we know it. From the development of stem cell therapies to the reconstruction of organs using cells and biomaterials, regenerative medicine holds the key to a new way of practicing medicine.[1,2,3] Additionally, regenerative medicine is a truly multidisciplinary field. Scientists from a variety of backgrounds (biology, chemistry, physics, engineering and medicine to name a few) come together to identify potential solutions and strategies for many of the complex health issues that we are faced with in today's society. For these reasons, regenerative medicine is an optimal topic for use in inspiring, engaging and educating K-12 students on what opportunities may await them if they pursue a STEM discipline in college.

Although, several websites contain background information on regenerative medicine[4,5,6,7] which can be useful as a starting point for educating students about the vast reach and potential for this multidisciplinary field, the information provided on these web sites are typically textual with graphics or scientific videos and do not provide the level of engagement and interface with the user necessary to actively involve the attention of a middle and high school audience for any significant length of time. They also do not offer any means for students or teachers to test their knowledge of the material presented since the sites are not constructed with any quiz based software. Based on the review of existing web-based, regenerative medicine resources, it is evident that a need exists for a new form of electronic resource, one that will not only engage and inform the middle and high school student and teacher population on regenerative medicine but also provide opportunities to obtain direct feedback in real time on their understanding of the subject matter.

A key area of regenerative medicine that we felt needed to be focused on immediately was that of stem cells. This subject matter unlike many other scientific topics tends to be strongly related to people's moral values. It has also been found that the general understanding of stem cell research has decreased recently from 64% in 2008 to 54% in 2010 according to the 2012 National Science Foundation Science and Engineering Indicators Report. [8] This is a very pressing problem considering the rapid developments occurring within the stem cell science field and the fact that many people within the general public will be faced at some point in their lifetime about a decision related to stem cells.

Professor Regen and the Nemesis Hunt: A Stem Cell E-Learning Module

Initiated by Pittsburgh Tissue Engineering Initiative's (PTEI) and in partnership with OpenArc, we developed a website called the "Starfish Schoolhouse" through supplemental funding received from the NIH Science Education Partnership Award (Grant# 3R25RR023286-05S1). This web-based platform, hosted as part of PTEI's, "If a Starfish Can Grow a New Arm than Why Can't I?" project featuring interactive, permanent and travelling science center exhibits,

classroom curricula and teacher professional development, provides middle and high school students and teachers an immersive, web-based, story-driven approach to learn about regenerative medicine.

The first module developed as part of this web-based platform is entitled, "Professor Regen and the Nemesis Hunt". In building this module we identified three learning objectives: (1) to allow students to be able to differentiate between the different types of stem cells; (2) have students identify methods used to isolate stem cells; and (3) enable students to be able to identify advantages and disadvantages of the use of each type of stem cell in regenerative medicine practice. Although the module developed provides similar background information on stem cells as all of the other regenerative medicine websites, it does this through a story-driven approach that captures students' attention right from the title screen (Figure 1).

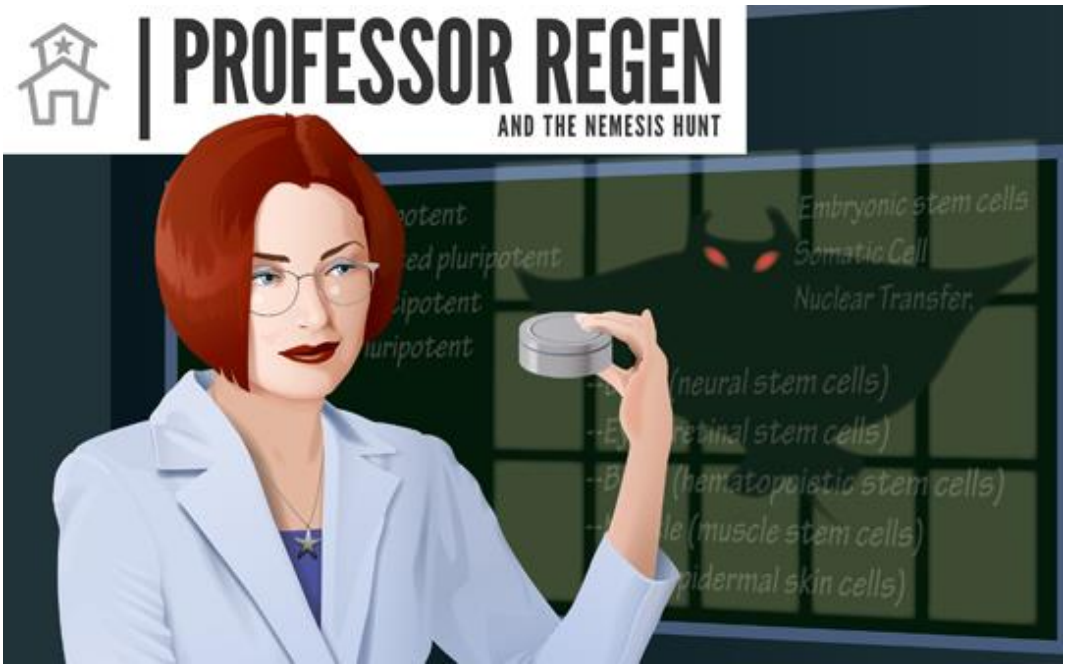

Figure 1. Title Screen for Professor Regen and the Nemesis Hunt Stem Cell Learning Module

Integration of stories or narratives for education is not a new pedagogy. However, the possibility of using narrative centered learning environments outside of the literary sciences has really been examined only in the past few decades. The benefits of narrative include the ability to transport the reader to another place and time and to experience the emotions of the characters as if they are living within the story. It is these features of narratives that have led them to having such strong potential in education as they are closely linked to memory and the ability to provide supporting structures for new content and material.[9]

In particular, the use of narrative for science education has started to gain momentum for its ability to make science meaningful and relevant to the general public.[10] Through the use of stories it is possible to break down many of the barriers that exist about science and open up

students to the realm of possibilities that can exist for them in science related fields. It also helps demonstrate that science is in itself an inquiry based process and that the individuals responsible for many of the key discoveries recognized in science textbooks today did not achieve these results on their first attempt and had to persevere through many failures to achieve success.[11]

In Professor Regen and the Nemesis Hunt, the students are introduced to the central character of the Starfish Schoolhouse series, Professor Regen. She is a female scientist who is director of a lab focused on the study of stem cells. The main character, Professor Regen, provides middle and high school students and teachers a picture that not only men can be successful scientists. Science and research provide strong career paths for women as well. The module also introduces Dr. Nikos Nemesis, a former student of Professor Regen, who is resentful of Dr. Regen's success and notoriety. As such, Dr. Nemesis deploys a number of strategies all aimed at disrupting Dr. Regen's research program. The story for this specific module reveals Dr. Nemesis stealing several different kinds of stem cell lines from Professor Regen's lab in her absence and then leaving them in various sites around "Anyville", the city the story takes place in. The story commences with Professor Regen entering her lab and discovering stem cells are missing and then beginning on a search around Anyville in search of the missing stem cell lines. As students are swept up in determining where within "Anyville" they should head to next to locate the missing stem cells, they are presented with key pieces of information about the different types of stem cells and their relevant properties that are important for their use as potential therapies.

In total the module consists of seven distinct chapters that provide an overview of stem cells along with specific details on the following stem cell types: embryonic stem cells, fetal stem cells, induced pluripotent stem cells and adult stem cells. Alongside the story based environment, the module contains chapter quizzes that allow for students and teachers to test the knowledge that they have learned about stem cells. These chapter quizzes consist of randomized questions drawn from individual question banks developed for material covered in each chapter. It has been well documented that the more users respond to content the greater the chance of them retaining it.[12] A quote that emphasizes this process is from Confucius in 451 B.C. "What I hear, I forget; What I see, I remember; but what I do I understand."[13] In addition, upon completion of the story, the module has a master quiz for participants to take that contains randomized questions drawn from a master question bank that contains all the questions developed for each chapter hence allowing this master quiz to cover all the stem cell material presented within the module. This last means of assessment provides the participants with a clear picture of their understanding of the subject matter and areas that they may want to go back and review.

Assessment Strategy

In partnership with the Learning Research and Development Center (LRDC), the stem cell module will be tested with both middle and high school teachers and students during the early

part of 2013 to determine its capability at meeting its learning objectives. The module contains a registration system that will allow for data to be collected on the participant working through the module, their choice of order in completing the chapters and whether they went back to any specific chapters to refresh their memory. This registration system will allow for the evaluator to get a broader picture of participants' use of the module and whether there were particular chapters that drew the attention of the participants more than others. In addition, the assessment will consist of participants taking an initial survey to collect baseline measurements on what they know about stem cells, how they learned this information and any misconceptions that they might have about the subject matter. The external evaluator from the LRDC will then observe the participants while they work through the module. Upon completion of the module, all participants will take a post survey to determine if there were any improvements in their knowledge related to the specified learning objectives.

The proposed assessment plan will be conducted with middle and high school teachers and students in an effort to learn what areas of the module captured the most attention, whether the module helped increase participants' interest in regenerative medicine and what areas of the module could be improved prior to broader dissemination. Human subjects' approval (IRB) will be obtained prior to any data collection.

Acknowledgements

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