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Zombie Apocalypse: Engaging Students In Environmental Health And Increasing Scientific Literacy Through The Use Of Cultural Hooks And Authentic Challenge Based Learning Strategies

Harriet Whiley
Flinders University, harriet.whiley@flinders.edu.au

Donald Houston
Flinders University, don.j.houston@outlook.com

Anna Smith
Flinders University, anna.smith@flinders.edu.au

Kirstin Ross
Flinders University, kirstin.ross@flinders.edu.au

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Abstract

Environmental Health (EH) is an essential profession for protecting human health and yet as a discipline it is under-recognised, overlooked and misunderstood. Too few students undertake EH studies, culminating in a dearth of qualified Environmental Health Officers (EHOs) in Australia. A major deterrent to students enrolling in EH courses is a lack of appreciation of the relevance to their own lives. This is symptomatic of a wider problem of scientific literacy: the relevance gap and how to bridge it. Employing a cultural hook offers a means to connect students to science and the fundamental elements of EH. Zombies feature prominently in the contemporary cultural landscape – movies, TV, gaming, music, cosplay, 'Zombie Marches'. A Zombie Apocalypse provides an engaging platform to convey key EH concepts such as microbes and toxins, whilst improving the scientific literacy skills of both science and non-science students. Engaging students through this cultural hook bridged the relevance gap, connected students to science, and inspired an increased interest in EH.

Keywords

curriculum design, scientific literacy, student engagement, Environmental Health

Introduction

Researchers have for many years advocated encouraging students of all disciplines to engage with science and develop their scientific literacy (Holbrook & Rannikmae 2009; Miller 1998). Even students who are not considering a career in science can benefit from understanding science and the scientific method (Jack et al., 2016, p. 1-24, Willoughby and Johnson, 2017, p. 461-468). The ability to “understand the news of the day as it relates to science” is an essential attribute, one which imbues graduates with the capacity to engage and contribute fully within society (Kolstø, 2001, p. 291-310). It has become even more pertinent with the rise of the internet and social media, because, as Britt et al. (2014, p. 104-122) note, “credible research and reporting competes with amateur blogs, entertainment summaries, and outright misrepresentation for public attention and resources”. It is becoming more crucial that civic scientific literacy is a graduate attribute if graduates are to play their part as contributing citizens in a meaningful and critical way.

“STEM is critical to our future,” writes the Office of the Chief Scientist (Office of the Chief Scientist, 2013, p. 12). Understanding scientific debates is becoming as paramount “as being able to read” (Hazen and Trefil, 1991, p.xi). However, prospective students often view disciplines within the sciences as dull and irrelevant (Barmby et al., 2008, p. 1075-1093). A key question for academics deeply committed to and embedded in the sciences is how to bridge the relevance gap. Environmental health (EH) is a discipline that addresses fundamental humanitarian and societal needs (World Health Organisation, 2017), yet the issues that typify EH – disease, poverty, pollution – do not necessarily affect students directly or seem relevant to them in their immediate experience. Consequently, too few students undertake EH studies, culminating in a dearth of qualified environmental health officers in Australia (Bartosak, 2012, p.11). Embracing opportunity within challenge, we set about redesigning an EH subject – Microbes and Toxins – with the dual intention of attracting science and non-science students to EH and increasing scientific literacy by placing EH in a meaningful and appealing context without sacrificing scientific and pedagogic rigour.

Background: scientific literacy and environmental health

The notion of “scientific literacy” first appeared 60 years ago in the US, with its origins likely in Cold War concerns for the public support of scientific progress and competition with the Soviet Union. In the 1990s an argument appeared for the promotion of scientific understanding as it pertains to societal concerns (Laugksch, 2000, p. 71-94). Although dated, Hazen and Trefil’s (1991, p.xii) definition of scientific literacy still articulates it clearly: “If you can understand the news of the day as it relates to science, if you can take articles with headlines about genetic engineering and the ozone hole and put them in a meaningful context – in short, if you can treat news about science in the same way that you treat everything else that comes over your horizon, then as far as we are concerned you are scientifically literate.” Nevertheless, scientific literacy remains invisible and seemingly irrelevant in and to the lives of many contemporary students. The key challenge in designing an educational experience to develop scientific literacy is to get potential students past “boring” (Barmby et al., 2008, p. 1075-1093, Tytler, 2007, p.10).

We approached our subject redesign with the deliberate intention of engaging with science and non-science students, acquainting them with each other and to the real-world application of science. We designed the curriculum to give students an understanding of the nuance of scientific research: that experiments often do not work, why controls and replicates are required, that “[r]eal science, like any human activity, tends to be a little messy around the edges” (Hazen and Trefil, 1991, p.xx). Allchin (2011, p. 518-542) identified the need to inform students about the complexity and reliability of scientific practise so that they can understand how to prevent, mitigate or accommodate error, and explored how this in turn influences the interpretation of results (Allchin, 2011, p. 518-542). This includes an understanding of basic statistical methods, uncertainty, significance, control of variables, predictions, hypotheses and conclusions. Providing an opportunity for authentic scientific inquiry enables students to gain an understanding of the nature of science (Erduran and Dagher, 2014, p. 1-18).

In addition to communicating the "messiness" of scientific discovery, our intent was also to engage students by demonstrating how science affects human life. EH presents an ideal vehicle for this, as it addresses all the physical, chemical and biological factors in the environment that can potentially affect human health (World Health Organisation, 2017). The World Health Organisation (WHO) offers abundant statistics: 26% of deaths among children under five can be attributed to modifiable environmental risk factors such as air, water and soil pollution, chemical exposure, climate change and UV radiation (Prüss-Üstün and Corvalán, 2006, p.x). Further, an estimated 12.6 million deaths each year – nearly one in four of total global deaths – are attributable to unhealthy environments (World Health Organisation, 2017). Figures like this will increase as climate change affects the distribution of malaria-carrying mosquitos, natural disasters (disrupting drinking-water distribution and increasing the spread of sewage, asbestos and vermin), food security and safety. The WHO (2014, p.43) estimates that by 2030 climate change is expected to cause an estimated 250,000 additional deaths per year attributable to environmental-health issues including malnutrition, malaria, diarrhoea and heat stress. The keys to combatting these threats lie in EH solutions, and yet, incredibly, EH remains overlooked and under-recognised (Resnick et al., 2009, p. S40-S45, Sheridan et al., 2014, p. 47).

In our subject redesign, finding a means to create a sense of relevance for students became paramount. We sought a means to engage potential students who otherwise may not have considered EH with the idea of enrolling in the subject. There is extensive literature on curriculum design elements that can be used to engage students once they are in a subject, such as an interactive learning environments, authentic situated assessment tasks and opportunities for staff-student and student-student interactions (Fung, 2017, p. 11, Goodyear, 2015, p. 27-50, O'Neill, 2015, p.35), but the curriculum-design literature provides little guidance on how to interest them in enrolling in the first place (Barnett and Coate, 2004, p.14). The challenges had as much to do with marketing as design. To encourage students to consider voluntarily enrolling in a science subject, we created a subject that had a contemporary cultural hook: surviving a zombie apocalypse.

The theory: educationally and theoretically justified zombies

To theoretically ground our subject redesign we turned to Biggs (1996, p. 347-364). His 3P model of teaching and learning articulates three aspects: presage, process and product. Presage is what exists before teaching and learning occurs. The model identifies two aspects of presage: student factors, including prior knowledge, ability and motivation, and teaching context, including learning objectives, assessment, climate/ethos and teaching. The model acknowledges the importance of the interactions between these two aspects. Managing the interaction – in this case, bridging the gap between what might interest and motivate potential students and what could be offered –provided the initial challenge in the subject redesign. Hick's (2007) revision of the Biggs (1996, p. 347-364) 3P model adds context as an element within student factors. Attention to context from the student point of view provided the opportunity to recontextualise EH and science literacy: surviving a zombie apocalypse provided a connected context to the students. Zombies feature prominently in the contemporary cultural landscape – movies, TV, gaming, music, cosplay, "zombie marches", Halloween. Zombies are both widely recognised and intriguing, with a "global currency" (Murphy, 2018, p. 44-57) and economic value estimated in the billions (OGG, 2011, p.). Zombies are deployed in the teaching of science to primary and secondary school age students (Martin et al., 2016, p. 1364-1384). Zombie iconography is both pervasive and appealing to students, and we deliberately employed it to exploit this familiarity.

Biggs's 3P model emerged during a shift in thinking about higher education in the late 1990s. Focus began to move from teaching (part of the process) to learning (the outcomes) (Banathy, 1999, p. 133, Barr and Tagg, 1995, p. 12-26, Biggs, 1996, p. 347-364, Biggs, 1999, p. 57-75). Bowden and Marton's (1998, p. 160-185) "university of learning" emphasised the university as a learning environment and the need to design assessment, closely integrated with teaching and learning, as a mechanism for future learning. Attention began to shift to specific changes in curriculum design and teaching practice that "develop students' capabilities for engaging in effective action in situations in the future" (Bowden and Marton, 1998, p. 137). Biggs's model embedded the new emphasis on learning-focused activities geared towards the promotion of deep learning: the model emphasised "what the student does" as critical to quality learning. Our subject redesign captured the concept of "what the student does" in a key design feature: a series of challenge scenarios requiring students to practically and theoretically engage with the science required to survive a zombie apocalypse (described more fully below).

To support our design, we applied Biggs's concept of "constructive alignment" of assessment, content and learning interactions with intended learning outcomes (Biggs (1996, p. 347-364) Biggs (1999, p. 57-75). He advocated careful thinking to create a learning environment that supports and encourages students to construct meaning and achieve higher-order learning outcomes, and described an aligned system as a fully criterion referenced system, where objectives define what we should be teaching; how we should be teaching it; and how we could know how well students have learned it. There is maximum consistency throughout the system (1999, p. 57-75). Biggs's model placed objectives/outcomes at the centre of the system and constructed teaching, learning and assessment around them. Similarly, Barr and Tagg (1995, p. 12-26) asserted that the learning paradigm conceives of academic staff first as designers of learning environments to promote learning and student success. In redesigning our subject we willingly assumed the role of learning-environment designer, with the conscious intent of promoting engagement and relevance.

While Biggs emphasised that assessment and grading should identify and acknowledge the students' learning progress and achievement, he did not provide an explicit framework of broad curriculum content areas to guide the development of learning outcomes and "moments in the student experience" (Barnett et al., 2001, p. 435-449). Barnett et al. (2001, p. 435-449) addressed this gap by proposing a curriculum model built on "an understanding of modern curricula as an educational project forming [student] identities found in three domains: those of knowledge, action and self". These domains in turn encompass discipline-specific content, competences acquired through doing (e.g., broader communication capabilities) and development of students' educational identity. They noted that the balance and integration of domains needs to be carefully considered in each curriculum.

The models proposed by Biggs (1999, p. 57-75), Hicks (2007) and Barnett et al. (2001, p. 435-449) can be seen as complementary, interacting layers of considerations framing curriculum design and implementation, as well as the students' experiences of the curriculum. Prideaux (2003, p. 268) argued that the fundamental purpose of curriculum development is to ensure that students

receive integrated, coherent learning experiences that contribute towards their personal, academic and professional learning and development. He further argued that care needs to be taken to ensure close alignment between the design, delivery and student experience of the curriculum. Houston (2004) argued that seeing a curriculum as a bridge to learning is a useful concept to bring to the design process: a curriculum, like a bridge, should ease the journey to learning for students, have solid foundations and structural integrity and fit its environment.
The design, building and experience of the curriculum need to be relevant to the students' environment, and users need to be encouraged to use it – especially if alternative, more immediately appealing options exist, it needs to be well signposted (marketed) and the experience needs to be true to the marketing. Our Zombie Apocalypse course engaged the students in finding the bridge, signposted the way to it and contextualised the students' journey across it.

The design: using contemporary cultural hooks to make topic content relevant and meaningful

Given what we knew about the importance of EH and the value of scientific literacy, together with a firm grasp of pedagogic theory, we committed ourselves to delivering teaching content and developing resources in a dynamic, engaging and appealing way to motivate and inspire our students. Our objective with the design of this subject was to bring important concepts of EH to students in a way that made sense – that related to them "in a purposeful way" (Ramsden, 2003, p.).

From the beginning, we strove to avoid a rigid teaching strategy of information transmission of the kind disparaged by Ramsden (2003) and defined as "Level 1" teaching by Biggs (2011, p. 30). Our vision was one in which students were not mere spectators but active and enthusiastic agents in learning: talking about it, writing about it, relating it to past experiences and applying it to their daily lives (Chickering and Gamson, 1987, p. 7). We adopted an intrinsic, rather than extrinsic, approach to motivating our students to learn (Wlodkowski, 1985, p. 1-6) in that we sought to place their perspective at the centre of the learning environment. We wanted our students to find life in their learning, and, ironically perhaps, we decided zombies were the way to do this.

The media is captivated by catastrophe, preoccupied with apocalypse. Dystopic stories of climate change, humanitarian tragedy and natural disaster are repeated endlessly. At the core of these real and profound threats lie solutions based in EH skills, techniques and knowledge (International Federation of Environmental Health, 2006). It was clear to us that a zombie apocalypse threatening the survival of a group of humans would be an ideal medium through which to teach the EH concepts so vital to solving many real-world problems.

Zombies feature prominently in the contemporary cultural landscape – movies, TV, gaming, music, cosplay, "zombie marches". They are both widely recognised and intriguing. The EH discipline encompasses subject matter spanning toxins and pathogens, microbiological processes, environmental hazards, water quality, emergency management and human-health outcomes. It is no great leap to draw a connection between these topics and an apocalyptic scenario involving death, disaster and the walking dead. A zombie apocalypse provides the perfect platform to convey key EH concepts, whilst improving the scientific-literacy skills of both science and non-science students. It represents a hook to both capture the attention of potential students and provide the theme running through and drawing together elements of the intended student learning experience.

Much has been written on the use of popular culture in teaching and as a means to convey information. More often than not, the writer is concerned with critiquing popular culture through a particular disciplinary lens: using the idea of superheroes to examine ethical practices, for instance (Burton, 2008, p. 7). We were not examining popular culture through a lens; instead, we were using a popular-culture icon as a medium through which to convey EH concepts.

Rather than stand back and examine the impact of disaster and threat, we immerse our students in it. We designed scenarios and challenges to represent EH issues associated with emergency management (Wisner and Adams, 2002). Students became the survivors of a zombie apocalypse and were required within this scenario to learn and use EH techniques to provide potable water, forage and preserve edible food, devise public health notifications, test for chemical exposure and determine best methods for waste management. By harnessing a contemporary cultural hook we engaged our students in the learning, exposing them to vital and authentic concepts in a creative and dynamic way whilst at the same time raising the profile of this under-recognised discipline.

The detail: ENVS2741 Zombie Apocalypse: Microbes and Toxins

The scenario given to students was that Adelaide – the city in which our main campus is located – had been invaded by zombies, and most of the remaining population was now living in hiding in the buildings at our university. The “authenticity” of the scenario was enhanced by specifically referring to the characteristics of our main campus. It is located on a steep ridge on the edge of the outer suburbs of the city bordering open fields and scrub. There is one access road onto the ridge. The main building precincts are positioned on two spur ridges on opposite sides of an artificial lake. The 1960s public-works architecture of the early buildings gives it a sense of solidity and persistence. The grounds include glades of trees and open grasslands. It could well provide sanctuary in an apocalypse.

Figure 1 shows the subject description, educational aims and expected learning outcomes as presented to students. The success of the contemporary cultural hook of the zombie-apocalypse scenario was illustrated by the interest it generated on social media prior to its commencement (Figure 2). The topic redesign also translated into a significant increase in student numbers, as shown in Figure 3. The 26 students who enrolled in the topic came from seven different degree courses (Figure 4). The previous version of the topic, named simply “Microbes and Toxins”, had consistently attracted around 10 enrolments each year.

The topic covered the basics of environmental microbiology and toxicology, and aimed to provide students with the skills to survive a zombie apocalypse. There were seven challenge-based scenarios designed around EH issues associated with emergency management. These were current and existing issues that significantly affect human health after natural or technological disasters (Table 1): creating safe drinking water; placement and design of toilets; testing food for chemical contamination; understanding vaccines and public-health campaigns; monitoring chemical exposures; food preservation methods; and food safety. To illustrate, the safe drinking water scenario required students to collect water from the artificial lake on campus and decide how to treat the water to make it potable. There are a number of different ways to do this, but in summary drinking water must be both filtered and disinfected to be safe to drink. Students needed to consider the health implications of their chosen methods and confirm the safety of their treated water through testing.

ENVS2741 Zombie Apocalypse: Microbes and Toxins

Topic description

Adelaide has been invaded by Zombies, and most of the population is now living in hiding in the buildings at Flinders University. It is your responsibility to provide safe drinking water and safe foraged and preserved food. You will learn techniques testing and preservation and biological monitoring. This topic will teach you the basics of environmental microbiology and toxicology, which will allow you to survive if there is a Zombie Apocalypse

Educational Aims

The aims for this topic are for students to:

1. Develop survival techniques for use in the event of a Zombie Apocalypse
2. Discover ways to protect public health by drinking water treatment
3. Determine the best methods to preserve foods and the microbial and toxicological implications of presentation
4. Determine and undertake toxicity testing of foods and water
5. Appreciate and describe the variety of microorganisms found in various environments
6. Appreciate the methods available to determine toxicity and their limitations

Expected Learning Outcomes

At the completion of this topic, students are expected to be able to:

1. Identify the main microbiological processes
2. Understand how these processes lead to both positive and negative human health outcomes
3. Identify the main toxicological processes associated with environmental chemicals
4. Understand the mechanisms by which these processes lead to negative human and environmental outcomes and how these can be monitored

Figure 1. Educational aims and expected learning outcomes for the topic Zombie Apocalypse: Microbes and Toxins

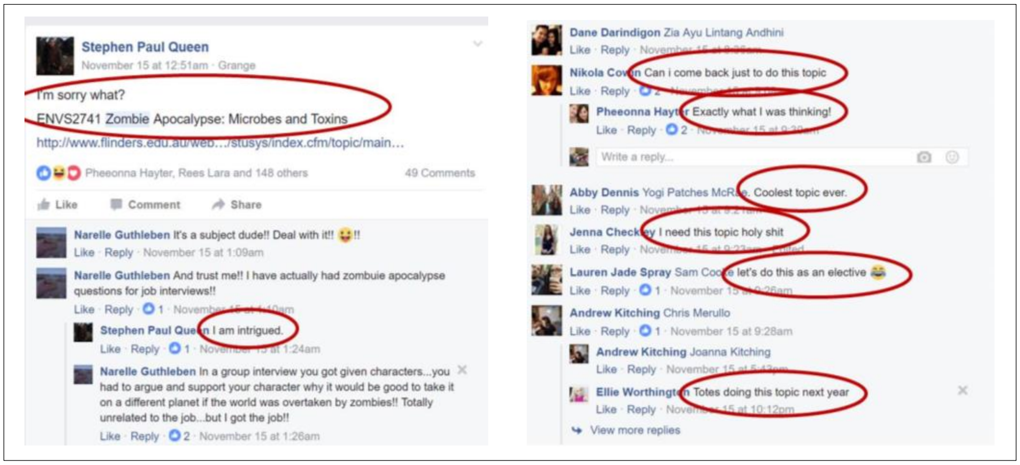

Figure 2. Comments posted about ENVS: 2741 Zombie Apocalypse: Microbes and Toxins on the "Overheard at Flinders University" Facebook page

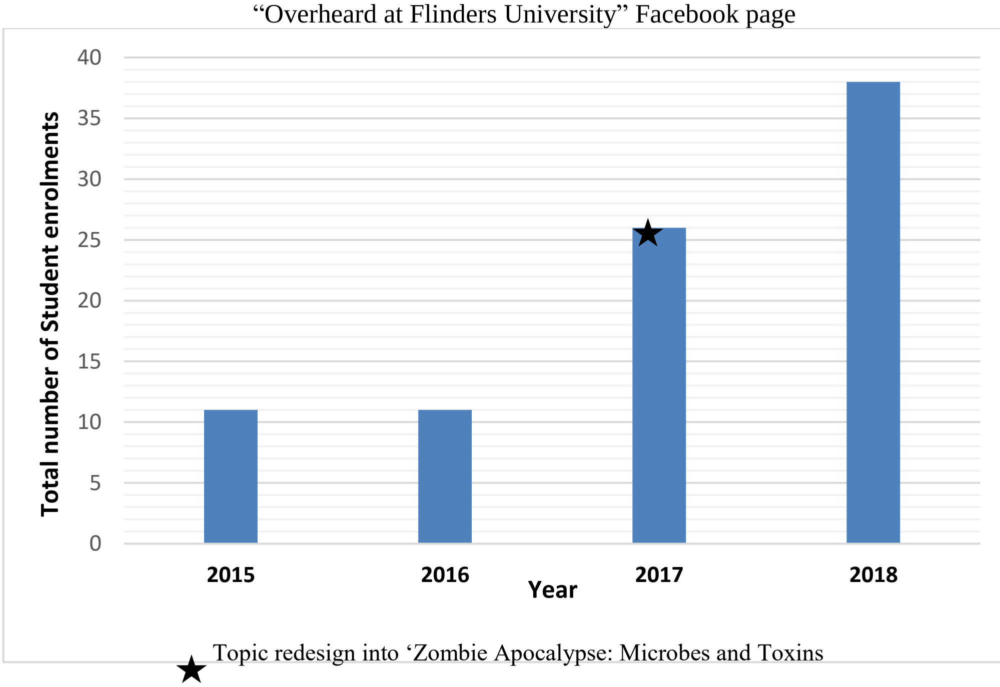

Figure 3. Student enrolment for the topic prior to (2015 and 2016) and after the topic redesign and launch of ENVS: 2741 Zombie Apocalypse: Microbes and Toxins in 2017

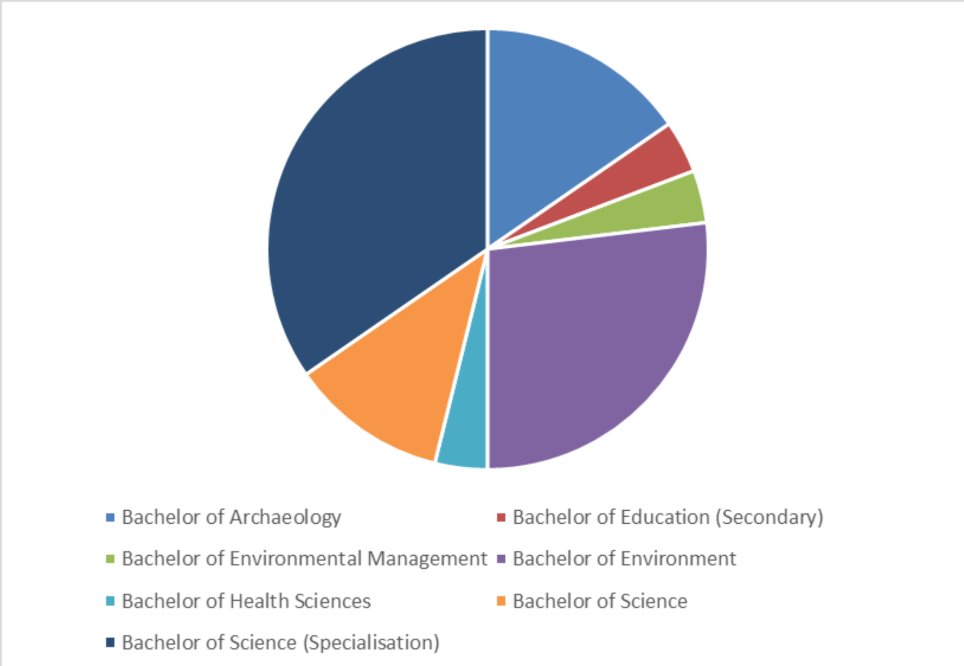

Figure 4. Student enrolment in ENVS: 274 Zombie Apocalypse: Microbes and Toxins

Student interest and engagement

Each scenario within the topic was designed to be exciting, engaging and entertaining for students, and were chosen for their relevance to EH, prompting students to consider aspects of their own lives through an EH lens. Feedback from students who completed the topic showed that the scenarios enabled them to see the relevance and real-world application of the skills they were learning: “The whole premise of the zombie apocalypse made the topic content relevant and applicable” (student feedback ENVS2741 2017). Immersing students in the scenarios enabled student-led exploration and discovery, conveying the importance of EH and its interrelation with and impact on humanity in a way that a standard lecture format could never achieve. Students who completed the subject were absorbed in EH concepts and learning from the beginning, and many have gone on to pursue EH research as a direct result.

Skill development

We designed the scenarios not only to be engaging, but also to facilitate the development of crucial science literacy and “soft skills”. Table 1 outlines the different scenarios in the zombie apocalypse and identifies how each scenario uses scientific knowledge and capabilities, including scientific reasoning, conceptual understanding, problem-solving, process skills, hypothesis-testing, information-gathering and statistical analysis (De Jong and Van Joolingen, 1998, p. 179-201, Lawson et al., 2000, p. 81-101, Zimmerman, 2000, p. 99-149).

Table 1. Overview of the scientific capabilities, soft skills and basic and applied knowledge students developed for each scenario in the zombie apocalypse

Description of challenge scenario	Scientific knowledge and capabilities (De Jong and Van Joolingen, 1998, p. 179-201, Lawson et al., 2000, p. 81-101, Zimmerman, 2000, p. 99-149)	"Soft" skills as identified by John and Chen (2017, p.	Basic knowledge (microbiology and toxicology)	Applied knowledge (practical context)
Safe drinking water The first thing you need to survive is safe drinking water. However, the potable water supply is contaminated, so you must collect water from the environment and treat it so it is safe to drink. You are going to collect water from the lake, take it back to the lab and make it safe to drink. How you make it safe is up to you. In your group, spend the next few days working out how you are going to treat the water. You have access to all the equipment in the lab, and in addition, you need to upload a list of any extra things you require three days before the lab. The total class budget is $500; therefore your spending limit is $50.	Scientific reasoning Conceptual understanding Problem-solving Process skills Hypothesis-testing Information-gathering	Teamwork Communication Knowledge retention Accuracy Efficiency Analytical skills Organisational skills Competency Time management Mathematical skill Accounting Decision-making Role plays Work ethic Problem-solving	Water pathogens Water-quality indicators Disinfection and disinfection by-products toxicology	Safe drinking water Emergency management
Toilet waste Where to put the toilets? The next challenge is to create a human waste management system. Your group needs to decide what is the best treatment system and where is the best place on campus to locate the system.	Scientific reasoning Conceptual understanding Problem-solving Process skills Hypothesis-testing Information-gathering	Teamwork Communication Knowledge retention Empathy Efficiency Organisational skills Competency Time management Mathematical skills Decision-making Role plays Work ethic Problem-solving	Pathogens Infectious disease Surface and ground-water contamination Water reuse Faecal reuse/composting	Onsite waste-water applications Emergency management Mass gathering Social and cultural context/considerations
Contaminated food Can I eat that? Not far from the university on South Road there is an abundance of watermelons. However, the soil at some of the sites in the area has historically been contaminated due to industrial processes. You now need to work out how whether the watermelons are safe to eat. To do this, you will use a toxicity test called Microtox(R). This will be demonstrated and undertaken in the lab. You will need to take notes so that you can write this up as a report.	Scientific reasoning Conceptual understanding Problem-solving Process skills Hypothesis-testing Information-gathering Statistical analysis	Communication Knowledge retention Accuracy Technical writing Efficiency Analytical skills Organisational skills Competency Time management Mathematical skills Decision-making Role plays Work ethic Problem-solving	Basic toxicological principles (No Observed Effect Level (NOEL), Lowest Observed Effect Level (LOEL), Lethal Concentration 50 (LC50)) Dose response Toxicological uptake and distribution in plants/food	Site contamination Foodborne-outbreak investigation

Vaccine assignment An effective injectable, single-dose vaccine against the zombie virus has been developed. However, rumours have started that say the vaccine causes cerebral atrophy and that the vaccine is a ploy by the government to control the human population by making everyone more stupid. This is not true. Your job is to produce a pamphlet, a letter, a radio advertisement or a television advertisement to convince people to receive the vaccine.	Conceptual understanding Problem-solving Process skills Hypothesis-testing Information-gathering	Communication Knowledge retention Empathy Efficiency Organisational skills Competency Time management Decision-making Role plays Work ethic Problem-solving	How vaccines work Herd immunity	Public-health messages Risk communication Social determinants of health
Chemical exposure The military have been using sarin gas against the zombies and it is possible that you have also been exposed. To test this you will measure the acetyl cholinesterase (AChE) activity in your blood using a commercially available kit. This will be demonstrated and then undertaken in the lab. You will need to take notes so that you can write this up as a report.	Scientific reasoning Conceptual understanding Problem-solving Process skills Hypothesis-testing Information-gathering Statistical analysis	Communication Knowledge retention Accuracy Technical writing Efficiency Analytical skills Organisational skills Competency Time management Role plays Work ethic Problem-solving	Toxicological principles (absorptions, distribution, metabolism and elimination/excretion) Biological monitoring vs. environmental monitoring Biomarker of exposure vs. biomarker of effect	Toxicity by design (pesticides, chemical warfare etc.) Food production Risk assessment (exposure assessment)
Food preservation There is not enough power for refrigerators, as such; you need to work out other ways to preserve perishable food. Your group will be given a fish fillet that you have to preserve. How you treat the fish is up to you and your group. You have access to all the equipment in the lab, and in addition, you need to upload a list of any extra things you require a minimum of three days before the lab; your budget is $50.	Scientific reasoning Conceptual understanding Problem-solving Process skills Hypothesis-testing Information-gathering	Teamwork Communication Knowledge retention Efficiency Organisational skills Competency Time management Accounting Decision-making Role plays Work ethic Problem-solving	Foodborne pathogens Extrinsic and intrinsic microbiological factors (water activity , pH, NaCl)	Food safety and security
Food safety You are foraging in the forest and find an abundance of mushrooms. They look delicious and would make an amazing meal – how can you work out if they are toxic or not? You will need to write this up as a report.	Scientific reasoning Conceptual understanding Problem-solving Process skills Hypothesis-testing Information-gathering	Teamwork Communication Knowledge retention Accuracy Technical writing Efficiency Analytical skills Organisational skills Competency Time management Mathematical skills Decision-making Role plays Work ethic Problem-solving	Mycology Taxonomy Identification Basic chemistry (colorimetric indicators)	Food safety and security Risk communication

Table 1 shows the opportunities for the development of "soft skills" that were incorporated into the topic design. These include teamwork, communication, knowledge retention, accuracy, efficiency, analytical skills, organisationals skills, competency, time management, mathematical skill, accounting, decision-making, role plays, work ethic, problem-solving, empathy and technical writing (John and Chen, 2017). To illustrate, the vaccination scenario requires students to create an advertisement to encourage the general population to receive a vaccination against the zombie virus. Students can create a pamphlet, a letter, a radio advertisement or a television advertisement to convince people to receive the vaccine. They are encouraged to work in teams. This allows students to develop the skills of presenting difficult-to-understand science in lay terms, working in teams to identify member strengths and creating a persuasive argument.

The development of these "soft skills" is essential for student development, but also graduate employability. The International Employer Barometer survey reports that 86% of employers considered good communication skills to be vital, and that "soft skills" were even more important than many "hard skills" (Scott, 2002, p. 61-75). However, 30% of employers have been found to have problems with graduates' skills in teamwork, communication and problem-solving (Forbes and Kubler, 2006). Our subject is ideally suited to develop these skills in students, given the mixed enrolment from both science and non-science backgrounds (Figure 2), resulting in students developing communication skills with other students from completely different backgrounds and educational experiences. The success of "soft skill" development is illustrated by student feedback that showed that 100% of students surveyed after completing the topic either "agreed" or "strongly agreed" that the subject successfully "developed my ability to think critically and analytically". This is further supported by one student's comment: "[T]here was a large self-learning aspect to this topic which helped my ability to think critically" (student feedback from ENVS2741 2017). The overall success of the topic is also illustrated by all students actively participating in and succeeding at each challenge scenario. This, along with increasing student enrolment (Figure 3), indicates that we achieved the design aim of getting non-science students to engage with scientific literacy.

We designed the zombie-apocalypse scenarios to enable the coverage of a wide range of basic microbiology and toxicology principles, presented in an applied manner. For example, in the contaminated-food scenario, students are introduced to basic toxicological standards and principles, including dose response and toxicological uptake and distribution in plants and foods. The coverage of such basic principles through this EH-based and problem-based learning lens quickly resulted in a student-led discussion on the real-world relevance of these concepts with regards to food safety and site contamination. It raised awareness amongst the students of the significance of EH in a context familiar to them.
The safe-drinking-water scenario requires students to consider;

- Filtration, or the removal of particles. This is crucial because particles bind with disinfectants and render them unable to act on bacteria.
- Disinfection, or the killing of bacteria; however, different disinfectants have different modes of action.
- The human-health consequences of disinfectants, as some are toxic to humans at high concentrations and thus must be used at the appropriate concentrations.
- Testing to confirm the safety of the treated water, including the limitations of routine testing, such as limit of detection, contamination, dilutions and the appropriateness of using indicator organisms to protect public health.

These components require students to understand the chemistry behind disinfectants, modes of action, reaction chemistry, dose response and toxicity. It also requires that they understand basic microbiology, such as cell structure and function, sample collection and processing, aseptic technique, limits of detection and statistical significance. These are all fundamental scientific concepts that students from non-science backgrounds might otherwise not be attracted to or engaged in, but the zombie-apocalypse scenario hooks them.

Reflections on the designed, delivered and experienced curriculum

The detailed design and delivery of the zombie subject were intended to reflect and enable key ideas from the higher-education curriculum research outlined above. The design was underpinned by Biggs's (1996, p. 347-364) key concept of constructive alignment, in which the relationships between what the student does (learning activities and processes), gauging and guiding student learning (assessment) and what students should take from the experience (learning outcomes) are brought together harmoniously to enable students to construct knowledge and understanding. The curriculum elements were connected to help students develop their scientific literacy through the lens of environmental health and the students' immersion in EH activities.

Constructive alignment is a crucial idea drawing together key elements of Biggs's and, later, Hicks's representation of the 3P (Presage, Process, Product) model. Our reflection on the delivery and student experience of the subject, as well as the students' responses to their own experience, strongly suggest that we got the Process part of the model right. The detail of the design captured in Table 1 emphasised the intent to develop skills in Barnett and Coates's (2004) action domain of outcomes through active student learning, and their self-domain through encouraging students to think about EH issues and to enhance their scientific literacy. The detailed design, delivery and experience of the curriculum moved and made connections beyond the knowledge domain of knowing and doing microbiology and toxicology. However, the formally documented subject aim (what the experience was intended to do) and learning outcomes that the students should take from the experience remained largely within that knowledge domain. This anomaly has since been rectified to bring the formal documentation into line with the detailed design as delivered and experienced. The official description of the anticipated Product of the 3P model – student learning from the subject – now matches much more closely with the learning that students actually experience and gain. This also illustrates the need to maintain a dynamic relationship between the three stages (or states) of the curriculum described by Prideaux (2003, p. 268): the formal specification of the design now more closely aligns with an improved curriculum as delivered and experienced.

With regard to the Presage element of the 3P model, the disciplinary content and focus of the model did not fundamentally change from the previous incarnation, nor did the cohort of potential students. What did change was the way the topic was presented to potential students: the public profile (the name) and the positioning of the topic in relation to potential students' contexts and interests. In other words, the topic was marketed differently. Marketing is essentially a process of satisfying organisational objectives by identifying consumers' needs and wants and managing relationships to satisfy them effectively. The teaching team's objective was to enhance students' scientific literacy through exposure to EH, but the potential students didn't want "microbes and toxins". So, instead they were offered a zombie apocalypse; they wanted that. This potentially points to a significant gap in the 3P model and the need for another P – profiling/positioning – to encourage students to come through the door into learning experiences that they might not otherwise realise that they need or want.

Conclusion

Our Zombie Apocalypse subject successfully engaged students by using a carefully designed, theoretically grounded approach incorporating a contemporary cultural hook and challenge-based learning. Students engaged with the learning material through real-world contextual immersion. As learning environment designers, we acknowledged the requirement for scientific literacy for both future employment and critical citizenship, and we took both science and non-science students closer to this goal without sacrificing either content or scientific and pedagogic rigour.

Student responses to the subject through various media, including Facebook and student evaluations of teaching, suggest that introducing the cultural hook had the desired effect of luring students into a learning environment where they were able to engage with experiences that delved into Barnett et al.'s domains of learning outcomes. In the domain of action, students produced media to communicate scientific ideas to broader audiences and developed communication skills to work across disciplinary boundaries. In the domain of self and educational identity, they explored the relevance of science to their own lives and the lives of others. Student reaction to the next offering of the subject will provide more data on the effectiveness of the design hook.

Arguably the key insight to come from our experience is that the substance and rigour of a subject do not need to be compromised to attract students to study outside their comfort zone. A contemporary cultural hook can be used as a mechanism to draw students in to the unfamiliar by placing it in a context meaningful to them. Other examples of pitching and contextualising science differently include the "Saving Nemo" (http://www.savingnemo.org/) program, which aims to engage the broader community as "citizen-scientists" in marine biology education and research. This, of course, relates to the enduring popular success of "Finding Nemo", the animated movie of 2003. Similarly, other colleagues have linked to the popular interest in television series involving crime-scene investigation and analysis to promote the discipline of forensic chemistry to high-school students. The critical consideration is to find, exploit and maintain a meaningful connection to students' lives and contexts – to lure them into otherwise potentially invisible, irrelevant or "boring" disciplines and "bridge the relevance gap".

References

Allchin, D 2011, 'Evaluating knowledge of the nature of (whole) science'. *Science Education,* vol. 95**,** no. 3, pp. 518-542.

Banathy, BH 1999, 'Systems thinking in higher education: learning comes to focus'. *Systems Research and Behavioral Science,* vol. 16**,** no. 2, pp. 133.

Barmby, P, Kind, PM & Jones, K 2008, 'Examining Changing Attitudes in Secondary School Science'. *International Journal of Science Education,* vol. 30**,** no.8, pp. 1075-1093.

Barnett, R & Coate, K 2004, *Engaging the curriculum*, McGraw-Hill Education (UK).

Barnett, R, Parry, G & Coate, K 2001, 'Conceptualising curriculum change'. *Teaching in Higher Education,* vol. 6**,** no. 4, pp. 435-449.

Barr, RB & Tagg, J 1995, 'From teaching to learning—A new paradigm for undergraduate education'. *Change: The magazine of higher learning,* vol. 27**,** no. 6, pp. 12-26.

Bartosak, C 2012. Environmental Health Workforce Attraction and Retention -Research Paper.

Biggs, J 1996, 'Enhancing teaching through constructive alignment'. *Higher education,* vol. 32**,** no. 3, pp. 347-364.

Biggs, J 1999, 'What the student does: Teaching for enhanced learning'. *Higher education research & development,* vol. 18**,** no.1, pp. 57-75.

Biggs, JB 2011, *Teaching for quality learning at university: What the student does*, McGraw-Hill Education (UK).

Bowden, J & Marton, F 1998, *The University of Learning: Beyond quality and competence in university education,* London, UK, Kogan Page.

Britt, MA, Richter, T & Rouet, J-F 2014, 'Scientific literacy: The role of goal-directed reading and evaluation in understanding scientific information'. *Educational Psychologist,* vol. 49**,** no.2, pp. 104-122.

Burton, CH 2008, 'Superhero as metaphor: Using creative pedagogies to engage'. *International Journal for the Scholarship of Teaching and Learning,* vol. 2**,** no.2, pp. 7.

Chickering, AW & Gamson, ZF 1987, 'Seven principles for good practice in undergraduate education'. *AAHE bulletin,* vol. 3**,** pp. 7.

De Jong, T & Van Joolingen, WR 1998, 'Scientific discovery learning with computer simulations of conceptual domains'. *Review of educational research,* vol. 68**,** no.2, pp. 179-201.

Erduran, S & Dagher, ZR 2014, Reconceptualizing nature of science for science education. *Reconceptualizing the Nature of Science for Science Education.* Springer.

Forbes, P & Kubler, B 2006, 'Degrees of Skill, Student Employability Profiles'. *CIHE, Graduate Prospects and Higher Education Academy, London.*

Fung, D 2017, *A connected curriculum for higher education*, UCL Press.

Goodyear, P 2015, 'Teaching as design'. *Herdsa review of higher education,* vol. 2**,** pp. 27-50.

Hazen, RM & Trefil, J 1991, *Science matters: Achieving scientific literacy,* New York, USA, Anchor Books.

Hicks, O. Curriculum in higher education in Australia-Hello?', paper presented to the Enhancing Higher Education, Theory and Scholarship. Proceedings of the 30th HERDSA Annual Conference, 2007.

Houston, D. Building better bridges: why curriculum matters. Proceedings of the Association for Engineering Education in Southeast and East Asia and the Pacific Mid-Term Conference, Auckland, New Zealand, 2004.

International Federation of Environmental Health 2006. IFEH Declaration on Climate Change. *IFEH Policy No 9,.* Dublin, Ireland, .

Jack, BM, Lee, L, Yang, K-K & Lin, H-S 2016, 'A Science for Citizenship Model: Assessing the Effects of Benefits, Risks, and Trust for Predicting Students' Interest in and Understanding of Science-Related Content'. *Research in Science Education,* vol.47, no.5, pp. 965-988.

John, DD & Chen, Y 2017. STEM Education Redefined. *Article number 19304.* USA: American Society for Engineering Education.

Kolstø, SD 2001, 'Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues'. *Science education,* vol. 85**,** no.3, pp. 291-310.

Laugksch, RC 2000, 'Scientific literacy: A conceptual overview'. *Science education,* vol. 84**,** no.1, pp. 71-94.

Lawson, AE, Clark, B, Cramer-Meldrum, E, Falconer, KA, Sequist, JM & Kwon, YJ 2000, 'Development of scientific reasoning in college biology: Do two levels of general hypothesis-testing skills exist?'. *Journal of research in Science Teaching,* vol. 37**,** no.1, pp. 81-101.

Martin, AJ, Durksen, TL, Williamson, D, Kiss, J & Ginns, P 2016, 'The role of a museum-based science education program in promoting content knowledge and science motivation'. *Journal of Research in Science Teaching,* vol. 53**,** no. 9, pp. 1364-1384.

Murphy, PD 2018, 'Lessons from the Zombie Apocalypse in Global Popular Culture: An Environmental Discourse Approach to the Walking Dead'. *Environmental Communication,* vol. 12**,** no. 1, pp. 44-57.

O'neill, G 2015. Curriculum design in higher education: Theory to Practice. University College Dublin. Teaching and Learning.

Office of the Chief Scientist 2013. Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach,. Canberra: Australian Government.

Ogg, JC. 2011. Zombies worth over $5 billion to economy. *NBC News*,.

Prideaux, D 2003, 'ABC of learning and teaching in medicine: Curriculum design'. *BMJ: British Medical Journal*, vol. 326**,** no. 7383, pp. 268.

Prüss-Üstün, A & Corvalán, C 2006, 'Preventing disease through healthy environments'. *Towards an estimate of the environmental burden of disease.* World Health Organization, Geneva, Switzerland.

Ramsden, P 2003, *Learning to teach in higher education*, Routledge.

Resnick, BA, Zablotsky, J & Burke, TA 2009, 'Protecting and promoting the nation's health: the environmental public health workforce as a critical component'. *Journal of Public Health Management and Practice,* vol. 15**,** no. 6, pp. S40-S45.

Scott, P 2002, 'The future of general education in mass higher education systems'. *Higher Education Policy,* vol. 15**,** no.1, pp. 61-75.

Sheridan, P, Wilcox, L, Gray, I & Dhesi, S 2014, 'Health protection'. in Sim, F & Wright, J (eds) *Working in Public Health: An Introduction to Careers in Public Health.* Routledge.

Tytler, R 2007, 'Re-imagining science education: Engaging students in science for Australia's future'. *Lab-talk,* vol. 51, no. 3, pp. 6-9.

Willoughby, SD & Johnson, K 2017, 'Epistemic beliefs of non-STEM majors regarding the nature of science: Where they are and what we can do'. *American Journal of Physics,* vol. 85**,** no. 6, pp. 461-468.

Wisner, B & Adams, J 2002, *Environmental health in emergencies and disasters: a practical guide,* Geneva, Switzerland, World health organization.

Wlodkowski, RJ 1985, 'How to plan motivational strategies for adult instruction'. *Performance Improvement,* vol. 24**,** no.9, pp. 1-6.

World Health Organization. (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. *World Health Organization*.viewed: http://www.who.int/iris/handle/10665/134014

World Health Organisation. 2017. *Public Health, Environmental and Social Determinants of Health*. Geneva, Switzerland. viewed: http://www.who.int/phe/en/.

Zimmerman, C 2000, 'The development of scientific reasoning skills'. *Developmental review,* vol. 20**,** no.1, pp. 99-149.