The Utility of Storytelling Strategies in the Biology Classroom

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Abstract

Conveying scientific information with high intrinsic cognitive load to students is a challenge. Often, students do not have the existing schema to incorporate the information in a comprehensive manner. One method that has shown promise is storytelling. Storytelling has been successfully used to convey public health information to non-experts. Therefore, it was of interest to determine whether storytelling could be used in the classroom to present information with high intrinsic load to students in a meaningful manner. This study used a post-test only quasi-experimental study design to explore the utility of storytelling as an instructional strategy in anatomy and physiology classes at a community college. Students in the treatment group received instruction that used storytelling to present examples of application. Both control and experimental groups were assessed through the use of a proximal formative quiz, distal multiple-choice questions, and a novel critical thinking exercise administered after the instruction. Results suggest that storytelling was as effective as the instructional methods delivered to the control group. These findings suggest that storytelling may be used as a means to convey complex scientific information in the classroom.

Keywords: *Storytelling; Instructional strategies; Instructional context; Problem-solving*

Introduction

Studies have shown that one of the major problems in communicating scientific information to students is the use of methodology that places the material out of cognitive reach resulting in a high intrinsic cognitive load (Avraamidou & Osborne, 2009; Brownell, Price, & Steinman, 2013; Bubela et al., 2009; Dahlstrom, 2014). Because much of the science that is being communicated has very little resemblance to everyday experiences, students have a difficult time constructing the necessary schemata to incorporate the information. Information is either misunderstood or dismissed since it does not fit existing schemata (e.g. the difficulty students have understanding evolution because it does not fit into a religious world view). One compensation technique for a lack of understanding is the rote memorization of facts. Unfortunately, memorization of individual facts isolates understanding and hampers the transfer of knowledge to novel situations (González, Palencia, Umaña, Galindo, & Villafrade M, 2008; Plomer, Jessen, Rangelov, & Meyer, 2010).

Storytelling has been explored as a way to bridge the gap between facts and understanding. Many of the empirical research exploring comprehension and storytelling in the sciences has looked at the use of narratives in public health campaigns (Betsch, Ulshöfer, Renkewitz, & Betsch, 2011; Hopfer, 2012; Mazor et al., 2007). Typically, scientists communicate their findings to students and the public the same way that they communicate their findings with their peers: data and statistics. While data driven decision making may be the norm in academia and business, there is evidence that among educated individuals (i.e. non-scientists) the presentation of statistical information is found confusing (Dahlstrom, 2014). In fact, studies have shown that the use of narratives is more persuasive than the presentation of statistical facts (Betsch et al., 2011; Hopfer, 2012; Mazor et al., 2007), and narratives may counteract the information given in statistical form (Betsch et al., 2011). In other words, information presented in narrative form is more compelling and believable than statistical evidence.

Unfortunately**,** storytelling is understudied and underutilized in higher education particularly in the sciences (Kokkotas, Rizaki, & Malamitsa, 2010; Krupa, 2014; Olson, 2015). One reason may be that storytelling is not seen as a scientifically rigorous topic or methodology to present information. For example, the aforementioned studies examining storytelling in public health campaigns use the terms “narratives” and “narration” instead of stories. Methodologies and teaching habits also tend to become embedded in disciplines. For example, it is not uncommon to hear otherwise highly educated individuals state that the way they present material is based on the tenant *this is simply how it is done* (Halpern & Hakel, 2003; Olson, 2015). The sciences may suffer from methodological inertia, resisting change. While not necessarily a weakness, one limitation in the literature is that most studies in storytelling are qualitative, and do not show a clear relationship to learning and retention. Furthermore, the studies that do try to quantify their results suffer from weak designs and very small sample sizes (Bower & Clark, 2013; Campbell & Hlusek, 2015; Kotluk & Kocakaya, 2015). Considering the inherent culture of experimental rigor in the sciences, this may be another reason for the unwillingness to adopt storytelling into the curriculum.

Storytelling has many benefits that allow listeners to effortlessly absorb information and incorporate it into their existing schemata. The use of storytelling or narratives has shown promise in public health campaigns (Betsch et al., 2011; Hopfer, 2012; Kreuter et al., 2007; Mazor et al., 2007) as well as learning language skills (Campbell & Hlusek, 2015; Hung, Hwang, & Huang, 2011; Hwang et al., 2016; Lee & Tseng, 2012; Mokhtar, Halim, & Kamarulzaman, 2011; Sadik, 2008; Tan, Lee, & Hung, 2014). It is important to examine storytelling as an alternative method to teaching scientific information to students in order to improve contextual meaning behind the information and to help construct the necessary schemata to incorporate the information.

Purpose of the Study

It is important to examine storytelling as an alternative method to teaching scientific information to students in order to improve contextual meaning behind the information and to help construct the necessary schemata to incorporate the information. A large number of studies exploring the use of storytelling as a instructional strategy have predominantly used qualitative methods (Catala, Theune, Gijlers, & Heylen, 2017; Chien, 2014; Henricsson & Claesson, 2016; Ian, 2015; Levitt & Piro, 2016; Shelby-Caffey, Ubeda, & Jenkins, 2014). The purpose of this study was to provide additional empirical evidence to the body of literature supporting the use of storytelling in conveying scientific information to non-experts and support the use of storytelling in undergraduate science classrooms. Prior studies mostly focus on improvements in motivation and self-reports to support the use of storytelling in the classroom. In order for the use of storytelling to advance in the sciences, it is imperative to provide evidence that it increases learning and retention of information.

The following research questions guided this study:

1. To what extent can storytelling increase learning in an undergraduate anatomy and physiology class?
2. To what extent can storytelling increase critical thinking skills in an undergraduate anatomy and physiology class?

Literature Review

One of the oldest forms of communication known to mankind, storytelling is part of the oral tradition of passing information from generation to generation in narrative form that predates written language (Abrahamson, 1998) and has been called the fundamental unit of communication between people (Avraamidou & Osborne, 2009; Kreuter et al., 2007). Even today, storytelling is a popular and powerful way to communicate ideas, information, and emotions as evidenced by the multitude of media using stories including books, movies, television programs, and internet channels. There are three fundamental components of stories that contribute to their popularity: resolution of conflict, high level of audience engagement, and extensive audience analysis (McDonald, 2009).

Conflict as a Means to Promote Critical Thinking

Conflict may take an overt form, as in the case of a paradoxical statement, but it may also be covert, like the internal struggle that an individual experiences when trying to relate new information to existing schemata. In the case of a story, conflict plays a pivotal role, without which, all that is being presented is a series of facts. Paradoxical stories (i.e. ones that have seemingly conflicting basis) may be used to pique individuals' curiosity and elicit deep discussion on a topic. The goal of the discussion would be to elicit a greater understanding of the material and to help the learner incorporate the information into existing schemata.

For example, in the case of a biology lesson, the instructor may present the class with a paradoxical situation based on the information recently presented and ask for a resolution. A more specific example would be asking students to explain how cows are able to build so much muscle eating nothing but grass. This is paradoxical because the building blocks of proteins necessary for building muscle are amino acids and grass is predominantly made of sugar and fiber. Therefore, cows should not be able to build the muscle mass based on their diet (body builders eat large quantities of protein, not salads).

Students would be encouraged to work in small groups to come up with resolutions to the problem and then report back to the entire class. The merits of their solutions could then be further debated as a whole group. These debates would expose misunderstandings as well as thought processes that the instructor could then correct or encourage. Through the use of stories and discussion students may increase comprehension of the information and therefore better incorporate the information into exiting schemata. It may even give insight into how the presentation of the information is perceived by the audience. This, in turn, would allow instructors to revamp instruction to better communicate the concepts.

Storytelling as a Way to Increase Student Engagement

Engagement is positively correlated with learning and information retention (Krupa, 2014; McDonald, 2009; Olson, 2015). Additionally, emotional engagement (i.e. eliciting an emotional response) has also been shown increase retention of the information (Lencioni, 2004; McDonald, 2009; Steidl, Razik, & Anderson, 2011). Stories are intended to engage the audience as well as elicit an emotional response. Therefore students can benefit from stories being used in courses not only to increase the above mentioned contextual comprehension of the material, but to also increase their engagement with the material and thereby increasing their learning and retention of the information (Lencioni, 2004; McDonald, 2009; Olson, 2015; Tan et al., 2014). This engagement may even promote learning outside the classroom as students are inspired to continue their understanding of a topic.

Audience Analysis

A fundamental principle of storytelling is to know your audience. Stories are often adapted to reflect the backgrounds, beliefs, and expectations of specific audiences. This is not unlike creating an audience analysis or developing personas in instructional design. Nevertheless, the audience analysis completed for storytelling is often more in depth than that in instructional design. Specifically, audience analysis for storytelling may exceed traditional analysis because often a goal of stories is to elicit an emotional response and therefore the audience analysis may even be described as having a level of empathy (McDonald, 2009; Parrish, 2006; Siegel, 1996).

Furthermore, one of the goals of storytelling is to make the listener feel as though they are being spoken directly to and feel as though they are one of a larger group of people. In the case of instructional storytelling, if done well, the story may help the learner better visualize the material and envision connections between the material being presented and prior knowledge. If students feel as though they are part of the narrative, they may feel greater ownership of their knowledge and feel more comfortable experimenting with and extrapolating the information to novel areas and topics. Additionally, if the learner feels connected and invested in the material, they may be more willing to independently pursue supplemental information outside of the classroom.

Storytelling as an Instructional Strategy

Currently the use of storytelling in education may be divided into two overarching categories. Storytelling is either used to assess student knowledge or it is used to deliver content. The benefit of using storytelling to assess knowledge is that the learner is required to take the information given and put it into their own words thereby requiring the learner to engage in higher levels of learning according to Bloom's taxonomy (i.e. creating materials versus simply understanding content). When done correctly, storytelling is a good tool to assess the transfer the knowledge. In other words, storytelling may be used as an extension of the constructivist ideal of the individual making their own meaning of a topic.

Most of the recently published studies on storytelling in education discuss the use digital storytelling to assess knowledge with very few publications examining the use of storytelling as a means of content delivery. One notable exception is a study conducted on college students in a biology classroom (Krupa, 2014). It is a notable exception not only because it uses storytelling to deliver content, but it also is one of the few studies that examine storytelling in the sciences in higher education.

Many of the empirical research exploring comprehension and storytelling in the sciences has looked at the use of narratives in public health campaigns (Betsch et al., 2011; Hopfer, 2012; Kreuter et al., 2007; Mazor et al., 2007). As mentioned earlier, it is typical for scientists to communicate their findings to students and the public in the form of data and statistics. While efficient, there is evidence that among non-scientists, using statistics to communicate information is found confusing (Dahlstrom, 2014)(Betsch et al., 2011; Hopfer, 2012; Mazor et al., 2007) and that information given in narrative form may counteract the information given in statistical form (Betsch et al., 2011). In other words, when information is presented in statistical versus narrative formats, individuals will preferentially trust the narrative rather than compelling statistical evidence. It is possible that narratives are seen as more truthful than statistical evidence because anecdotal information is easier to relate to on a personal level (Dahlstrom, 2010).

Benefits of Storytelling as an Instructional Strategy

One may think that the use of narrative, with superfluous details and imagery would increase intrinsic load and thereby decrease learning. However counterintuitive, there is evidence to suggest that use of narrative improves memory for instructional material (Dahlstrom, 2010). While the exact mechanism for the findings is unknown, it is possible that the improvement is due to the ability of stories to evoke vivid imagery which is easier to remember than individual facts. In fact, it has been shown that individuals are able to learn new facts from stories without prior exposure via traditional means with a similar degree of success as learning through traditional lecture methods (Marsh, 2003). This suggests that it stories may be used as the primary means of instruction and not simply as supplemental instructional material.

Furthermore, there is evidence that digital storytelling helps students improve their communication skills, increases their motivation as well as creates a social bond through shared experience (Campbell, 2012; de Lima et al., 2014; Hwang et al., 2016; Kilic, 2014; Mokhtar et al., 2011; Morais, 2015; Sadik, 2008). More specifically, the use of storytelling increased engagement in chemistry class in 8-10 year olds and, while not quantified, is hoped to prevent "chemophobia" or the fear of chemistry class (Morais, 2015). Unfortunately, many of these studies are qualitative and did not use control groups (Campbell, 2012; de Lima et al., 2014; Hwang et al., 2016; Kilic, 2014; Mokhtar et al., 2011; Morais, 2015; Sadik, 2008); therefore, the influence of storytelling on engagement cannot be unequivocally known.

Methods

Research Design

This post-test only quasi-experimental study used a control and an experimental group to explore the utility of storytelling as an instructional strategy in anatomy and physiology classes at a Southwestern community college. The treatment that was presented to the experimental group consisted of new instructional material that was delivered in a storytelling format. The control group did not receive any instruction that used a storytelling format as an instructional strategy. Dependent variables included scores on a quiz administered two days after the treatment and control lessons; multiple-choice questions on a lecture exam administered seven days after the treatment and control lessons; and a critical thinking short answer question administered on the same exam as the multiple-choice questions.

Participants and Setting

Upon receiving IRB approval, students enrolled in one of two human anatomy and physiology courses were used in the study. All students enrolled in human anatomy and physiology classes have had to pass the following criteria: institution reading requirement and introductory biology course completed and passed within the past five years (Table 1). Participation in the study was voluntary; however, students choosing not to participate were still required to complete the exercises but their data was not used.

Classes were of mixed gender and students ranged in age and experience in all three assessments. Some students recently graduated high school while others were non-traditional students returning to school looking to change careers. Nevertheless, all students had similar background knowledge in biology due to prerequisite requirements. While the site of research is an emerging Hispanic serving institution, the demographics near the site are predominantly Caucasian. Because both the treatment and control groups have the same instructor, differences between instructors may be excluded.

Table 1. Summary Information about Participants

Groups	Age Range	Gender (total number of participants)	Declared Majors	Total Number of Participants
Experimental	High school graduates to non-traditional adult learners	32 female 9 male	Nursing, General Studies, Dental Hygiene, Business, Associate of Arts, Biotechnology, Administration for Justice Studies, Undecided	27 – Quiz 32 – Multiple-choice 30 – Critical thinking question

Control	High school graduates to non-traditional adult learners	16 female 6 male	Nursing, General Studies, Dental Hygiene, Business, Associate of Arts, Associate of Science, Undecided	22 – Quiz 22 – Multiple-choice 17 – Critical thinking question

Procedures

Approval for the study was obtained by an Institutional Review Board at the primary research institution and the site of research. Upon approval, students were given consent forms and were explained the experiment. They were told that their grades would not be affected nor would identifying information be used in the study.

If students chose not to participate in the study, they still completed the activities and assessments with the rest of the class; however, their information was not used in the analysis. Students in both classes attend lecture and lab sections that are taught in a face-to-face format. One class had a maximum enrollment of 48 students and the other has a maximum of 24 students. The larger class was given the experimental treatment and the smaller class served as the control group.

The control group received a lecture (approximately 15 minutes) that consisted of information presented via PowerPoint along with examples (see Appendix A). Two days after the lecture was presented, the class was given a formative quiz to determine comprehension The experimental treatment (approximately 15 minutes) consisted of a lecture presented via a story (see Appendix A). Similarly, two days after the story was presented, the class was given a formative quiz using to determine comprehension. The quiz included including all of the material that were taught during that class. Total time for the quiz was approximately 20 minutes with 30 seconds per question. After each question the instructor gave an explanation of the correct answer before moving to the next question.

Both the experimental and control groups were also tested one week after instruction using a lecture exam that included materials from the first four weeks of the semester. The scores on the five questions were analyzed and compared between the control group and the treatment group. Additionally, to assess critical thinking, an extra credit question consisting of a related, yet novel, real-life situation given on the exam to both groups (see Appendix B). Total time for the lecture exam was 75 minutes with students having the freedom to allocate time to questions as individually needed. Exams were collected upon completion and students were allowed to leave the room afterwards. Answers were graded according to a rubric and were reviewed by a second subject matter expert to verify scores. The scores between reviewers was analyzed and found to be similar. Again, the scores were analyzed and compared between the control group and the treatment group.

Inter-subject transfer of information is minimized by the occurrence of the classes (i.e. one is held in the morning and the other in the evening on opposing days of the week). Summary of the experimental design is shown below in Table 2.

Table 2. Summary of Experimental Design

Groups	Max. Number of Participants	Treatment	Proximal Assessment	Distal Assessment	Critical Thinking Assessment
Experimental	32	Instruction in the form of a story	Quiz following instruction using – two days following treatment	Lecture exam questions – one week following treatment	Critical thinking extra credit question on lecture exam – one week following treatment
Control	22	Traditional lecture instruction	Quiz following instruction using – two days following traditional lecture	Lecture exam questions – one week following traditional lecture	Critical thinking extra credit question on lecture exam – one week following traditional lecture

Instruments

To test whether or not storytelling enhanced learning, a proximal and distal assessment was given. A proximal assessment was designed to measure the transfer of information, whereas the distal assessment was designed to measure the retention of information. The proximal formative assessment consisted of a Kahoot.it quiz given two days after the treatment or lecture was presented. Kahoot.it is an online program that allows an individual to create an unlimited number of multiple-choice questions. Students may log on to the quiz and participate as a group using their mobile devices or laptops. Individual questions must be answered in 30 seconds or less. Points are awarded for correctness as well as speed of answering. Response tallies are displayed as bar graphs and individual responses are recorded and available at the end of the quiz for download. The top five highest scores are displayed on the screen.

The lecture exam covered material taught in the first four weeks of the course. However, the exam included five multiple-choice questions specifically on the topic presented during the storytelling and control interventions. The entire class received one of two versions of the same exam. The two versions differed only in the order of the multiple-choice options. In other words, the answers were the same just in a different order. Students were also given a critical thinking question on the lecture exam that required analysis of a novel scenario (Appendix B). The novel scenario was based on an actual rare medical condition not specifically discussed in class.

Results

The Use of Storytelling to Increase Learning

This research question investigated the effect of storytelling on short-term (quiz) and middle-term (multiple-choice questions on a lecture exam) retention of information presented in class**.** Data for grades on the quiz and multiple-choice lecture exam were checked for outliers and normality. After examining histograms of the data, it was determined that the data contained no outliers and exhibited normality. A Mann-Whitney test indicated that the quiz scores of students who received instruction via storytelling (M=2.11, N=27) did not significantly differ from quiz scores of the control group (M=1.91, N=22) U=.300, p=.327, r=0.141. Similarly, the multiple-choice scores of students who received instruction via storytelling (M=2.81, N=32) and the control group (M=3.00, N=22) did not differ significantly U=.563, p=.582, r=-0.075.

The Use of Storytelling to Increase Critical Thinking

This research question investigated the effect of storytelling on a novel, critical thinking question given one week after instruction in class. Data was checked for outliers and normality and it was determined that there were no outliers and the data was normally distributed; however, Levene's test indicating that the data for the control and experimental groups had unequal levels of variance, F=.458, (p=.035) and, therefore, requiring the use of the Mann-Whitney U to determine significance. A Mann-Whitney test indicated that the scores of students who received instruction via storytelling (M=0.931, N=30) did not significantly differ from quiz scores of the control group (M=1.437, N=17) U=.351, p=.384, r=-0.128.

Discussion

The communication of complex scientific information to students is often burdened by a high intrinsic cognitive load and the lack of existing schemata to incorporate the information in a meaningful way (Avraamidou & Osborne, 2009). This is in-line with the principle of situated learning in that information is not consolidated into memory in a meaningful way because the information is presented in a context that is outside of real-life experiences (Driscoll, 2005). One of the strengths of stories and narratives is that they are developed with significant audience analysis and are therefore rooted in existing schemata and experiences. Using stories as a vehicle to deliver content with a high intrinsic load may help in learning, comprehension, and, ultimately, in the development of new schema by building on existing ones.

While the use of stories in education has often been limited to supplemental instruction, it has been shown that individuals are able to learn new facts from stories without prior exposure with a similar degree of success as learning through traditional lecture (Marsh, 2003). This suggests that stories may be used as the primary means of instruction and not simply as supplemental instructional material methods. The purpose of this study was to examine how storytelling could be used as a means to convey new instructional material in an undergraduate anatomy and physiology class.

Since storytelling traditionally has high levels of listener engagement, robust audience analysis, and relatable presentation of information, it was believed that storytelling would be able to convey information more effectively than traditional lecture methods as well as improve critical thinking in an anatomy and physiology class. While the study did not show an increase in learning or critical thinking, similar to other findings (Hung et al., 2011; Marsh, 2003), it did demonstrate that learning could occur from storytelling.

As mentioned earlier, one of the difficulties with communicating scientific information to students is that the information is often unfamiliar, may result in cognitive dissonance with belief systems, and is often presented with high intrinsic load (Avraamidou & Osborne, 2009; Brownell et al., 2013). Although storytelling is believed to alleviate these communication problems, the results suggest that there may be that a ceiling effect on comprehension due to the complexity of the information. In other words, regardless of the means of delivery, there may be a limit to what can be understood without further study outside the classroom. For example, students may comprehend the lesson taught; however, to fully grasp the interconnection with other biological systems, time must be spent outside the classroom to coalesce the related information. If this is the case, potential benefits of storytelling may lie with students spending more time with the material while creating stories themselves. This would support the findings of studies that has explored the use of storytelling in English language learning classes (Hwang et al., 2016; Mokhtar et al., 2011).

Implications for Teaching

Often, topics taught in science classes are presented in isolation of one another, leaving students to connect the pieces to form the overall, complex picture. However, because the content is often information dense, students tend to focus on memorizing individual facts rather than connecting the pieces to form a comprehensive narrative. To use a colloquialism, students often cannot see the forest for the trees. Not surprisingly, this can be frustrating for teachers and students alike, especially when critical thinking is a desired outcome. Storytelling may be a way to bridge the gap between related yet separate groups of information. Stories naturally link different ideas together in a situated context. Similarly, stories may be a simple and relatively easy method for students to link different scientific ideas together to form a coherent narrative.

Additionally, storytelling may aide instructors in presenting information dense content in an engaging manner. At times, it is difficult to avoid dry information dense lectures, especially in introductory classes where the students have little prior knowledge to engage in meaningful activities. The use of stories can make an otherwise unpalatable lesson, not only more meaningful, but also more interesting.

Finally, storytelling may also foster learning by allowing students to engage with the material at their own pace. For example, information presented in an interesting story would allow and encourage students to reread passages as needed before constructing their responses to critical thinking questions. Similarly, if students were constructing their own stories, they would be able to engage with the material at their own pace to demonstrate their understanding. This would not only allow for individualized activity but would also give the instructor insight into how students are perceiving and interpreting the information.

Limitations

A perennial classroom limitation is technology and this study was not immune to it. The initial experimental design called for the proximal assessment (quiz) to occur at the end of the class during which the treatment and control lecture was given. However, due to complications arising from devices being unable to connect to the internet, the first assessment had to be delayed until the next class period two days later. This delay may have muted the detection of improvements to early learning as the quiz may have been administered too far after initial instruction to observe an effect.

Another limitation may have been the method used to deliver the story. The story was told once, orally, during the treatment session, linearly, without the iteration of individual facts. While students had access to PowerPoints containing the information, a single presentation may not have been enough of an exposure for the participants of the treatment group. Similar to the use of narratives in public health studies, the students may have remembered the overall story without recalling individual facts.

Another reason for the possible failure to measure differences may be due to events occurring before the second assessment (i.e. lecture exam). Students in both groups were given five minutes before the lecture exam to ask the instructor questions on course material. Students in the control group asked specific questions relating to the topic used in the experiment whereas students in the experimental group did not. This may have led to higher scores in the control group since they received immediate feedback on their questions. This immediate feedback shortly before the exam likely made the identification of the correct answer much easier.

Future Research

As previously mentioned, the prior success of storytelling in the sciences has been in the communication of information in public health campaigns. However, the information that was retained by the participants was not shown to be specific detailed information, rather, storytelling was shown to influence decision making about health care choices (Betsch et al., 2011; Hopfer, 2012; Mazor et al., 2007). It may be similar with using storytelling in science education. The students may have remembered the overall story without recalling the individual facts. Furthermore, even though the experimental group showed similar levels of learning as the control group, their perception about the information may be different and may influence retention (i.e. persistence) in the course and even their decision to continue on in their coursework. Since positive emotional experiences (i.e. enjoyment of the class) act as rewards, according to behaviorist theory, individuals will seek out positive rewards and persist in their behavior. In other words, a positive view of the course or the information presented may translate into student retention. It would be interesting to examine the levels of engagement between the two groups as well as retention within the groups in future studies.

The long-term retention of information is seen as critical in education because often a lesson acts as a building block to future concepts. If instruction can help increase long-term retention, it could improve an individual's chances of better understanding information in future courses or situations. One of the barriers to long-term retention is the unsuccessful encoding of information. Encoding entails relating incoming new information to information already stored in the brain in such a way that it is easily memorable (Driscoll, 2005). Since storytelling uses familiar concepts to convey new information, it would be of interest to determine if storytelling affected long-term retention of information. Although not part of this study, a final exam was given approximately 3-months after the initial lesson and it included the aforementioned multiple-choice questions from the lecture exam.

Finally, it may be beneficial to determine if there would be a difference based on the delivery method. Again, a single oral telling may not be sufficient exposure to the material. Based on behaviorist theory, multiple exposures to the information in an individual setting with a self-paced format would increase the learning of the material especially if mastery of the content was required and clear and immediate feedback was given (Driscoll, 2005). It would be interesting to see if students are more successful at learning the material if the story was presented in a written format. Having the story in written format would allow students to progress through the information at an individual pace and would allow review of facts. As mentioned earlier, the benefits of storytelling may also lay in students constructing their own story from information learned. This activity would require students to interact with the information on a deeper cognitive level and would increase the time spent thinking about the material. Finally, receiving immediate feedback would allow students to learn from their mistakes and make adjustments according to instructor recommendations.

Conclusion

Students often have difficulty understanding and remembering concepts taught in science classes because of high intrinsic load and lack of existing schemata. Due to its emphasis on audience analysis and basis in existing schemata, storytelling is seen as a viable alternative method to traditional teaching techniques with the goal of improving learning and comprehension. The purpose of this study was to provide empirical evidence supporting the use of storytelling in conveying scientific information to non-experts and support the use of storytelling in undergraduate science classrooms. This study sought to address a gap in the literature by providing quantitative data to support the existing qualitative data showing the benefits of storytelling in educational settings.

In summary, similar to prior studies examining the effects of storytelling on student performance in English classes (Hung et al., 2011; Hwang et al., 2016), storytelling was shown to be as successful at conveying information to students as traditional lecture techniques as measured by scores on a quiz, multiple-choice questions, and a short answer critical thinking question. Four areas were identified for future research. While examining the possible benefits of storytelling on the transfer of scientific information to individuals is a priority, it is of equal importance to understand how storytelling may influence perceptions surrounding the scientific information. Similarly, it is of interest to determine how storytelling may influence perceptions and affect student retention in classes as well as the long-term retention of information. Finally, the impact of methods employed in using storytelling in science classes should also be examined to determine what works best.

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Appendix A
Case Studies

Experimental Group Lesson

Picture it. The zombie apocalypse is real. The corpses of recently deceased people have reanimated and walk the streets. Unlike some of the more recent films, these zombies are all very slow and their movements are very jerky and sudden. Their balance is off as they lurch in seemingly random directions looking for brains. Because they are so slow, as a single zombie, they are not a threat; however, because the disease is highly contagious and easily communicable through bodily fluids, zombies as a group pose a significant threat. They also feel no pain, so injuries do not stop them. They also show little understanding of or response to outside stimuli with the exception of olfactory and auditory cues that lead them to food. The only things that seems to stop them is severing the head, severely damaging the brain or allowing them to decay to a condition where they are no longer a threat.

Bob works in a biomedical research facility. He has been assigned to study the skin of zombies. As you may be aware, zombies do not have the greatest complexions. They are often seen with skin peeling from various body parts as they decay. The research facility has a secured area in which zombies are kept for use in experiments so Bob is able to get “fresh” skin samples to examine in the laboratory using powerful microscopes. In fact, the microscopes are so powerful that he is able to clearly see small protein structures that are embedded in the cell membrane of cells.

Typically, the healthy non-infected human skin has five different types of proteins holding it together. It is important that there are so many different types to ensure that fluids don’t leak in or out of the body and that the skin stays firmly attached to the connective tissue underneath. Just think about how many times a day you bump, pull or scratch your skin. If you didn’t have these proteins, your skin would peel right off just like a zombie’s skin. If you’ve ever had a burn or road rash, you know how much it stings not to have your skin there to protect you.

Bob takes the journey to the zombie holding area. There are about 10 rooms each with a single zombie in them. He talks to the person in charge and picks a zombie that has been relatively recently reanimated. He and a handler walk into the room and Bob cautiously walks up to the chained zombie. The zombie has a mouth guard like Hannibal Lecter wore in Silence of the Lambs, preventing it from being able to bite and chains keeping it secured to the wall. The handler tightens the chains so that the zombie can’t move as Bob hastily removes some skin samples from the zombie’s forearm. Despite working at the facility for some time, Bob is still slightly nauseated as he has to cut into a moving zombie. “It’s still too much like a human,” he mumbles to himself before heading back to his lab.

Bob prepares different microscope sections from the tissue that he removed and places the first under the microscope. He notices 5 different protein junctions on skin cells and muscle cells. Because the two tissues are physically close to one another, the first section that Bob looks at has a small piece of muscle attached to the skin. Looking at the muscle and comparing it to the skin, Bob notices a junction in cell membrane of muscle cells that is predominantly missing from skin cells. This junction looks like a tunnel, one that small molecules and fluids can pass through. Bob immediately recognizes it as a gap junction and realizes that muscle tissue need this type of junction so that they can coordinate contractions.

On the skin cells, Bob sees four different structural junctions. These junctions, he realizes, are there to hold the cells together. He also quickly realizes that depending on how decomposed the zombie is, some or all of these junctions are damaged or missing. The first transmembrane protein junction looks like a string of pearls holding the cell membrane of two adjacent cells very closely together. Since they are tightly held together (cell membranes are touching), Bob recognizes these proteins as tight junctions. “Hmmm,” thinks Bob. “I bet nothing can leak in between these cells.”

The next junction that he sees looks almost as if there was a belt going around the outside perimeter of the cell membrane. Again, he immediately recognizes this as an adherens junction due to its unique structure. “The adjacent cells look connected by these belts as if they were two halves of a ziplock bag,” Bob thinks to himself. As he looks closer, he can see that the protein belts are actually a structure called a plaque that is reinforced by microfilament strands made of actin. The belts are attached to one another in the intermembranous space (space between the two different cell membranes) by cadherin molecules (these are transmembrane proteins). “The cadherin molecules look like they zip together like teeth on a zipper,” Bob notes.

Moving around on the slide, Bob zooms in on a junction that looks like a snap button on a shirt. He sees circular plaque molecules on the cell membrane of adjacent cells reinforced by large strands of intermediate filament. Again, these circular plaque molecules are holding the cell membranes together using cadherin molecules in a zipper-like fashion. “I see. These kinda act like a spot weld holding two cells together. These must be desmosomes; which means that if I find half of one of these holding cells to the tissue below…those halves are hemidesmosomes.”

Control Group Lesson

Because your skin takes so much daily abuse, there are different types of proteins that help hold the individual cells together. There is also a 5th type that is more typically found in muscle tissue but it belongs to this category so we will discuss it here as well. The first connection type is called a tight junction. Take a look at the picture. A tight junction is a string of transmembrane proteins, not unlike a string of pearls holding two cell membranes together. Because of the way that tight junctions are structured, they make it impossible for fluids to leak in between cells. This is very important because it means that when you take a shower or bath or go swimming for example, you don’t soak up water like a sponge. You also don’t lose water which is also very important to minimize dehydration.

The next type of junction is an adherens junction. Its function is also to hold the cell membranes of adjacent cells together but it doesn’t hold the cell membranes as close together as a tight junction would. However, because of its structure, the adherens junction is pretty tough and it prevents cells from peeling away from one another or breaking apart, if you banged your arm against a wall for example. As you can see in the image below, the structure of an adherens junction is different from a tight junction. It consists of a protein plaque “belt” that runs along the perimeter of the cell membrane. The belt of one cell membrane lines up with the belt of an adjacent cell membrane. These belts are reinforced with microfilaments made of actin and adjacent belts are connected by cadherin transmembrane proteins (like a ziplock or a zipper).

The third type of junction is very similar to the adherens junction and is called a desmosome. It also has a protein plaque and cadherin transmembrane proteins holding adjacent cell membranes together. However, in the case of desmosomes, the protein plaque does not extend around the perimeter of the cell as a belt; rather, the protein plaque is found in small circular areas not unlike a snap button. One other difference is that the filament found in the plaque is the larger intermediate filament making the desmosome a very strong connection. Again, it helps hold cells together especially where there are a lot of contractions or stresses occurring.

The fourth type of junction is basically half a desmosome and so it is named a hemidesmosome. It is identical structurally to a desmosome; however, it differs in that instead of anchoring two adjacent cell membranes to one another, a hemidesmosome anchors the bottom layer of epithelial cells to the connective tissue below. Basically, this is the connection that is necessary to keep all of the epithelial tissues in your body from detaching from the connective tissue below.

Finally, the fifth type of junction is called a gap junction. This junction is a little different from the ones we mentioned because its primary purpose is not to anchor cells together but to create a passageway for ions and other fluids to move between cells. Gap junctions form a tunnel between the cell membrane of two cells, almost like one of those hamster tunnels. You find these kinds of connections in high numbers in muscle tissue where the transfer of ions between cells is crucial for synchronized contractions.

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