Encouraging scientific literacy and critical thinking through the examination of media

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Abstract

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This project, completed as part of a Master's in Education with a focus on Curriculum and Instruction, examines techniques to teach critical thinking through the lens of scientific literacy. The focus of the project is to teach students to appreciate the interconnectedness of science and to equip them with the skills to question the science they see and hear, especially from the media. It begins with a literature examination of how to teach critical thinking skills, the techniques of science, technology, society and environment (STSE), and how to question media. This review of the literature led to the creation of the project that encompasses three different activities: the first shows and discusses scientific discoveries and ideas presented in weekly You Tube videos, the second teaches students to look for and question scientific evidence in a variety of media sources, and the third has students use these skills to summarize, evaluate, and reflect on an article on a recent scientific discovery and have an online discussion about it with their peers. This project concludes with a professional reflection on the evolution of this project, the future implication and direction of the project, and some recommendations for others who want to incorporate aspects of this project into their own classrooms.

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Chapter 1: Introduction

Growing up I always felt a deep connection with science and how the world worked. I loved knowing and figuring out the interconnectedness of everything around me. This desire to learn more about science eventually led me to become a teacher which allows me to continue learning and to share my passion with my students, giving them their own opportunity to develop those deeper connections. While this has always been my goal, that is not always what I have been achieving as a high school science teacher.

In the science classroom, we often struggle to complete the course curriculum in our limited time frames, or we get overwhelmed in the details. As a result we don't often take the opportunity to explore our lens and to look at the big picture. Instead, we separate and isolate concepts from one another, even the disciplines are separated into chemistry, physics, biology and earth science; and yet in reality the lines between the subject areas and ideas blur. By becoming bogged down in the unique bits and pieces of the curriculum, I have limited time for helping students with what I found most important in the first place.

I ask myself, what do I want my students to come away with after they leave my class, and school in general? I want them to be able to see the bigger picture, all of the interconnectedness of how one thing might affect another, and I want them to find their own passion and appreciation for science.

I would love to teach my students all of the scientific truths of the universe, but since I can not, I need to focus less on knowledge mastery and more on skill development. In an age where information bombards us from every angle, they need to think for themselves; filtering this information, deciphering the good science from the bad, and always continuing to ask questions.

Critical Thinking

Critical thinking, and the process of evaluating information and learning to think for one's self, is a big part of science. Though critical thinking skills can often be recognized, they are not something that are necessarily easy to teach. There are some who question if critical thinking skills can even be taught, and while some people may be more naturally prone to it than others, it is something everyone can work on improving. Of course, as with most things in life, critical thinking is a process that must be practiced often, and there are various techniques that can be used to achieve this.

Unfortunately, in the classroom, little time is spent on actually developing critical thinking skills. Instead students focus on remembering the 'right' answers instead of being encouraged to think for themselves through their own individual paths as critical thinking encourages. Hopefully, this project will be a way of helping to change gears in order to spend more time on the process of science and less time focused on the product.

Science, Technology, Society and Environment (STSE)

To help students connect to the material on a deeper level and to see some of the interconnections, I would like to use some of the techniques of the Science, Technology, Society and Environment (STSE) approach. In this approach, the focus is on using socio-scientific issues to connect the concepts of science to the 'real' world. By using this approach, and bringing current science issues into the classroom, students will learn more than scientific concepts. They will begin to recognize interrelationships, and understand some of the impacts that society's choices can have on our world - now and in the future. With this approach students should also develop an understanding of the environment and the world, keeping it in mind as they encounter information, form opinions, and make decisions throughout their lives.

Media Literacy

Peer-reviewed journal articles are considered the best source for scientific information, yet they are not very accessible to the average citizen because of the background knowledge required and of course the time necessary to not only read, but locate and decipher these articles. Instead many people receive their scientific information captured through a variety of snippets and sound bites that they come across in the media through TV shows, commercials, movies, YouTube videos, and eye catching headlines on the internet. These clips and images may grab attention, but are not necessarily reliable sources for scientific material. More so, they do nothing to support critical thinking. While some portions of this information is interesting and provides viewers with valid content, a much greater portion of it is incomplete, incorrect, or intentionally deceptive. Whether it is coming from honest ignorance or dishonest agendas, this bad science is all around us and often sways readers' opinions with manipulated statistics, incomplete or biased information, and nonsensical info graphics. The only way for students to ward off this misinformation is to have the skills to recognize it, to acknowledge the source content, and to question the validity of what they encounter.

My Project

This past year I have started experimenting with a new routine of showing short You Tube videos in the classroom on a range of scientific topics. The videos are not selected on what makes immediate connections to the current material in the classroom or even the course itself, but on a variety of 'current' scientific topics that have thought provoking ideas or are presented in interesting ways. Exposing students to a wider range of topics, they are better enabled to make connections and find something that they are passionate about. By building on this idea of

presenting scientific information using media, students will be better skilled at connecting and interpreting the information around them.

Taking these ideas into account, I plan on creating new routines for the classroom that better build on what I have already begun with my presentation of You Tube videos. These will be presented along with two other activities spread through the course. One where students will learn how to dissect media articles for scientific evidence and the other, where students are given the opportunity to choose and analyze a scientific article of their own choosing and have a discussion about the science with their peers in an online discussion forum. All of these activities will be presented in such a way to help students see the big picture and the interconnectedness of Science. It will also help develop their critical thinking skills especially when presented with bad information from a variety of sources, particularly those from popular media. To do this I will first study the literature to define and identify critical thinking skills and explore what teachers can do to help develop theses skills in their students. I will then incorporate media literacy skills to help students navigate the information they are presented with, incorporating good as well as misleading science, and finally incorporating current more controversial science topics to encourage them to draw their own conclusions. By doing this they will achieve the skills they will need throughout their lives to continually ask questions and to see the big picture instead of the individual parts.

Chapter 2: Literature Review

Introduction

In today's world we are bombarded with information, although it all may appear factual, much of it is misleading or altogether wrong. So how do we identify the 'good' information from the 'bad', especially when it often seems to be 'scientifically proven'? Today we must question everything that we see or hear, and not accept it as blind truths. This mindset is something that many, especially adolescents, are not fully equipped to deal with. One of the many skills required is critical thinking, but what is the best way to teach someone to think critically, and what does thinking critically actually mean?

In this paper I will review some of the literature related to developing critical thinking skills especially in relation to media literacy. I will argue that being able to interpret and distinguish the good science from the bad, as well as being able to come up with one's own judgments, is vitally important, and that these are skills that must be formally taught and practiced. By doing this, students will have the ability to question the popularized science that they will run into in their everyday lives.

I will begin with an overview of critical thinking and what it means to think critically. I will then delve into why scholars believe critical thinking is such an important skill by connecting it to the student's world and society at large, and especially with media literacy. I will end with some strategies for teaching critical thinking such as the role of the teacher and the need for good frameworks. My argument will be made under a social constructivist framework as I believe that the very nature of science depends on the foundation that "individuals seek understanding of the world in which they live and work" (Creswell, 2013, p. 24).

What is Critical Thinking?

Critical thinking is a common term in the literature, but it is one that can be hard to grasp as well as define. Scholars take varied approaches to define critical thinking. In the mixed methods study done by Miri, David and Uri (2007) they comment that it is the skill of taking responsibility of one's own mind or a reflective thought process that focuses on deciding what to believe and what to act upon. They claim that critical thinking is a variety of skills and see it as a combination of truth seeking, open-mindedness, self-confidence and maturity. They believe that critical thinking "involves cognitive activity applied within a purposeful, inquiry-oriented interpretation of relevant information" (p. 367) and support the constructivist's view of education as getting away from textbooks and creating more student-centered opportunities as "students need to be exposed to learning experiences that enable them to construct their own knowledge and promote their thinking skills" (p. 354).

Thier (2008) takes a scientific approach to critical thinking and yet echoes Miri et al. idea of open-mindedness by equating critical thinking to having a healthy skepticism, one that "requires a delicate balance between being open to new ideas and also being doubtful of claims for which there is no clear and convincing evidence" (pp. 20-21). Terry (2012) furthers the link to evidence using Bloom's taxonomy and equates the process of evaluation to critical thinking as the examination of internal evidence for logical consistency (p. 66). This is echoed by Ertmer, Sadaf and Ertmer (2011) who found that higher level student responses were enabled by using higher levels of Bloom's taxonomy (p. 157). Morgan (1995, cited in Terry) goes on to say that "Every valid definition of critical thinking requires that students engage in a deeper processing of information than is often seen in traditional science education" (p. 66).

Connecting Science to Students and Society

In order for students to engage with the material, it must be relevant and must connect to their everyday lives. Teachers must tie science curricula to students' real-life experiences because when "students see the utility of scientific thought and reason in helping them make sense of their world, then … classrooms will be truly relevant" (Sperry, 2012, p. 56).

Kim, Yoon, Ji and Song (2012), examined the effect of their 'Everyday Science Class' (ESC) in Korea by observing learners' interaction and their response to learning subjects, especially within everyday contexts. They examined two classes with 20 students and 20 parents involved in this program over a 10 week period, and both video recorded the classes, and conducted 30-40 min interviews with some of the participants (eight students and three mothers). Kim et al. chose common everyday topics and materials to help the learners recognize that science is all around them, and they provided "opportunities to explore scientific explanations in relation to everyday phenomena [so that] their understandings of science became concrete and relevant to their life contexts" (p. 82). They also noticed that connecting science to the students' everyday world helped to motivate the student to learn more: "… we came to understand that their attitudes became more positive and willing to participate in learning and to know more about science in their surroundings" (p. 84) and that the "children revisited their learnt ideas and activities outside ESC classes and developed their own questions in their daily bases" (p. 85). Overall, Kim et al. found that the relevance of science to the students' own world, helped to improve the students' opinions and values towards science in general.

In the mixed method study conducted by Miri et al. (2007), they studied three classes of students in a rural high-school in Israel: one class of science students whose teacher put an emphasis on teaching critical thinking skills, one regular science class, and one non-science class.

They conducted pre- and post-tests to quantitatively gauge critical thinking skills, but they also conducted interviews with science and non-science teachers and made in-class observations. They found that the two science teachers relied heavily on making connections between the class material and everyday life by using inquiry-based learning and open-ended questions designed to encourage students to think (p. 362). Besides connecting the work to the students themselves and asking questions of the students, the teachers also encouraged students asking their own questions and questioning each other. They found that over their three-year study, the students' critical thinking skills (based on truth-seeking, open-mindedness, self-confidence and maturity) showed a greater increase for the group taught with an emphasis on critical thinking. As in the Kim et al. study, they found that it is important that the learner have the desire to think critically. If the student is not making a personal connection to the knowledge or the question, it is much easier to take a shallower approach to the situation, but if the student is connected to the information they are more likely to delve deeper into the problem.

Science, Technology, Society and Environment (STSE)

Another method that takes the idea of connecting the subject matter to students' lives is the Science, Technology, Society and Environment (STSE) approach. STSE is a philosophy towards science that emphasizes the teaching of scientific and technological developments in their political, economic, cultural, and most importantly, social contexts. It does this through exploring real world socio-scientific issues in the classroom and by placing science in a broader perspective. It seeks to "interpret science and technology as complex socially embedded enterprises" (Pedretti, 2003, p. 219), and strives to "promote the development of a critical, scientifically and technologically literate citizenry capable of understanding STSE issues,

empowered to make informed and responsible decisions, and able to act upon those decisions" (Pedretti, 2003, p. 219)**.**

Pedretti (2003), believes that the science classroom of today has become obsessed with the material and is less about connecting it to the world at large: "Little is done to convey to students that science is a human/social activity laden with values, beliefs and conventions, situated in a particular time, context and culture" (p. 220). In contrast the STSE approach helps students to be actively involved in their learning, and encourages them to apply that information (Terry, 2012, p. 66). It also creates opportunities for students to question the information that we give them so that they may become aware that knowledge, even scientific knowledge that is thought of as objective and factual, actually relies on "human emotions, imagination and intuition" (Pedretti, 2003, p. 227). As Dawson and Vencille (2010) mention, it is vitally important to equip our students with "…the understanding, skills and values that are needed to grapple with socio-scientific issues" (p. 134), especially since "…most environmental problems can be interpreted as social justice issues, with race/ethnicity, gender, and class often being the major factors determining who controls and benefits..." (p. 200).

Having students acquire the knowledge, in combination with the ethics behind a problem, allows them to further those connections and helps them to think for themselves instead of simply regurgitating information. This also allows students to see the multiple perspectives of an issue and that the diversity of people, each with their own set of values, leads to a variety of different possible outcomes (Jones, Buntting, Hipkins, McKim, Conner, & Saunders, 2012, p. 704). It forces them to become "transformed from the passive, technical, and apolitical orientation that is reflective of most students' school-based experiences to an active, critical, and politicized life-long endeavour that transcends the boundaries of classrooms and schools" (Kyle,

1996, cited in Hodson, 2010, p. 204). Furthermore, if these socio-scientific issues can be connected to the student's community, it has the potential to foster even more connections and "encourage[s] them to authentically and critically participate and engage in understanding, caring for, and transforming the world to which they belong" (Cook & Buck, 2010, p. 35). For STSE approach, it's power comes from the ability for students to gain understanding of the complexity of the world around them, connecting to it personally, and allowing them to make their own decisions about where they want their place in this world to be.

Interpreting Science in the Media

Miri et al. (2007) believe in the importance of critical thinking and state: "that the ability to think critically is becoming an imperative to success in modern life, as the pace of change continues to accelerate, and complexity and interdependence continues to intensify" (p. 356). The importance of the social connection must be further connected to the idea that the majority of information that students will receive in their lives comes from the media. Klosterman, Sadier and Brown (2012) point out that with the ever changing nature and relevancy of socio-scientific issues, there is a need for the most current resources possible that go beyond the usual outdated science textbook (p. 53). Sperry (2012) emphasizes this point when he says, "[t]oday more than ever, our students want their school experience to be relevant. They live and learn in a media-saturated environment where information abounds," but he also cautions that in these sources "wisdom is often lacking" (p. 56). Brossard and Scheufele (2013) offer that there are links to the amount of time spent on the internet to increased positive attitudes toward science, and further suggest that nontraditional online sources such as blogs and online-only media offer different perspectives and may be "helping to narrow knowledge gaps

caused partly by science coverage in traditional media that tends to be tailored to highly educated audiences" (p. 40).

The importance of perspective is echoed by Klosterman et al. (2012) as they believe that students must be made aware that media is socially constructed and that teachers must start "teaching **about** mass media—not just teaching **through** mass media" (p. 53). This is especially true as many media outlets, whether inadvertently or intentionally, give information that is incomplete, incorrect, or down right deceptive. When this misinformation is from a source with a large audience, there is the "potential to strongly influence what people think and [what] decisions they make" (p. 53). Caution and the ability to question this potential misinformation is more important than ever.

Majetic and Pellegrino (2014) recognize that some of the reasons for this incompleteness of information may be simply due to the very nature of the media itself as it tries to keep its audience's attention with short clips and sound bites. In these instances media reports often rely on stronger than warranted language and sensational headlines. They frequently do not take the time to describe the methodology, results, data, and bias to the reader. There is also the general quality of the reporting itself, especially if those reporting on the topic are not experts in the field. Because of this, it is important to teach students to ask the right questions and to search for additional information and sources so that they can have a more complete picture than what is being offered.

Thier (2008) furthers this discussion and stresses that exposure to media can help students develop an appreciation for varying perspectives, each with its own 'truth' dependent on the writer. She emphasizes that "[t]o be media literate, we must help students become adept at using a full range of literacy skills to navigate the sea of

messages that are designed to sway their beliefs and manipulate their emotions," (p.23) and that students need to learn to read "'beneath' the words on a printed page or listen 'behind' the words in a persuasive message" (p. 23).

How to Teach Critical Thinking Skills in Science?

Through these arguments it is apparent that not all media is created equal and it is important to teach students how to think critically and become media literate. There are various strategies in the literature when it comes to teaching critical thinking skills. I will outline a few of these strategies and have divided them into two categories: the role of the teacher, and the use of frameworks.

The Role of the Teacher. When it comes to how a class is run, and how the material is taught, the most important piece is always the teacher. For critical thinking, the best way to teach is "…by example, by example, and by more example. Model it, show it, do it. We need to show by example how we make decisions and solve problems with the students" (Van Allen, 1995, p. 109).

In the Dawson and Venville (2010) qualitative pilot study they help students make evidence-based decisions by teaching them critical thinking through argumentation. From previous research they knew that if a teacher did not have expertise in facilitating discussions, then there was the potential to inhibit a student's ability to use argumentation. Moreover, they found that teachers were reluctant "to consider social and ethical aspects of controversial issues because they felt that they did not have the skills to effectively use discussion" (p. 145). Their study hoped to prove that by giving a teacher additional professional development, they would be able to increase the teachers effectiveness in teaching these skills.

They conducted their case study on a year 10 science teacher and they began by first giving

this teacher a professional learning session in order to teach argumentation to two year 10 classes. The teacher then took two lessons to teach the principles of argumentation to his classes by using classroom discussions and writing frames on two sociocultural issues at the end of their unit on genetics. Extensive field notes were taken during the professional development seminar as well as during prelesson formation and the lessons themselves. Audiotapes of the two lessons were also taken. They found that after the teacher had taken the professional learning seminar he was more confident and was better equipped to teach argumentation using his new skills including: using students' names whenever they responded or asked a question; calling on all students during the lessons; rephrasing or restating a student answer so the whole class could hear; building on the students' responses by providing more evidence; taking on alternative positions; encouraging students to answer each other's questions; using humour; asking follow up questions; providing examples to help illustrate; and reminding students to use evidence (p. 144). They found an advantage of classroom discussion was that the teacher could "control and monitor all student input, ensure that students were on task and direct argument strategies to the whole class" (p. 145).

One of the major recommendations from the Dawson and Venville study, is the need for professional development to help teachers who are not comfortable with classroom discussion and sociocultural issues. This is echoed in the Miri et al. (2007) study which states: "We suggest that professional development programs would be structured in such a way that teachers will have a better understanding of what higher order thinking is, and would be able to conceptualize [critical thinking] in a more coherent way" (p. 367), as well as in the Jones et al. (2012) study which regarded the idea of teaching future thinking.

Jones et al. looked at three case studies in which a future studies unit was taught in various

classrooms: year 4 (8 year olds), year 10 (14 year olds), and year 12 (16 year olds). They used multiple data sources: conducting classroom observations and informal teacher/researcher as well as student/researcher discussions, including copies of teacher planning documents and student work, and obtaining student feedback through audio-recorded conversations or written questionnaires (p. 696). They found that their futures thinking framework (see Appendix A - Framework #1) could "be used to extend traditional approaches to science topics and encourage students to develop critical, reflective, and flexible responses to future-focused issues that affect them as individuals and as residents in local, national and global communities" (p. 706). However, they were also quick to note that it would only work if the teacher was also on board and that "[n]one of the teachers had previously included futures thinking in their lessons in a manner that could be defined as structured or directed" (p. 696) and therefore "teacher professional development is needed to ensure that students consider the multiple influences that contribute to socio-scientific issues" (p. 706).

In the article by Klosterman et al. (2012), they investigated several secondary teachers' use of non-traditional mass media in the science classroom, and specifically how these uses of media might help address socio-scientific issues. The first phase of the study involved interviewing six teachers about their use of media in the classroom while the second phase focused on three of the teacher's diverse and frequent use of media and technology over a nine-week period. Over this period, the classrooms were observed at least twice a week and detailed field notes were taken including video recordings, classroom artifacts, and supplement field notes (p. 59). In one of the classrooms the teacher found that the teacher provided instructions or guided questions to help the students engage with the media, including analyzing the content and the intended message. She also had them gauge the media's relevance, credibility and usability,

however she generally did not ask them to evaluate the media's accuracy, nor the author and intended audience (pp. 64-65). She did emphasize the concept of multiple perspectives and "encouraged her students to take a position and support it with evidence" (p. 66).

One of the other teachers used media frequently in her classroom, however "her instructional approaches with the media were limited, and she tended not to leverage media as a means of introducing [socio-scientific issues]" (p. 68). The third teacher had a very structured classroom but the lessons were usually less organized and he often gave the students little to no instruction on what to do with the information they received from the media source. Instead he would analyze the content, and though he wanted his students to do the same, they weren't always able to do so. Overall it was found that even though both the second and third teachers used media often in their classrooms, they did not do "much to capitalize on the [socio-scientific issues] as a learning opportunity or explore the affordances of the media to more fully engage students in the issue" (p. 70).

Besides giving students clear instructions on how to connect with and analyze the media sources, it was also found that it was very important how teachers went about engaging students in the process. For instance, in most of the cases reported in this study, the students accessed the media passively, as it was generally found and selected by the teacher. This studies echoes the work of Sadler (2009) when they caution that if:

> One of the goals of issues-based education is to prepare students for future encounters with new issues as they arise, [then] a key element of that preparation ought to be developing practices associated with finding new media sources, not just reading and interpreting media sources. (cited from Klosterman et al., 2012, p. 71)

They also found that in the process of analyzing and evaluating media, both students and teachers could be engaged in the process. However, during the creation of media, students were the ones most engaged, unfortunately creation was rarely seen in the observed classrooms.

The actual form of the media was also discussed and while the media used was often static print media, such as newspaper articles, the authors thought that "more dynamic media that offer teachers and students opportunities to actively participate in dialog and decision- making around contemporary issues … would be particularly well-suited for supporting student engagement with [socio-scientific issues]" (p. 71). Their statements also align with the other studies mentioned by concluding that professional development to research how to support teachers' innovations and "coordinat[e] [their] use of dynamic media practices and contextualized [socio-scientific] issues are certainly warranted" (p. 71) and that it will need to "be customized to respect differences in teacher assumptions and practices" (p. 71).

From several of the aforementioned articles, it is clear that there is a need for teachers to change their usual techniques of merely teaching content to a method that encourages students to make their own judgments. Sperry (2012) believes that many teachers struggle to shift their classroom practice from delivering information or giving their own interpretations to encouraging students to think for themselves with an inquiry-based approach. He further states that "teachers [need] to think of their students, rather than themselves, as the most effective vehicle for delivering key concepts and understanding to each other" (p. 58). Tolbert (2011) echoes this thought and affirms that

> the voice of the teacher and/or single text should not be the only one in the classroom—teachers should use multiple and even conflicting texts to encourage students to find and reflect on the main ideas of a variety of texts around the same topic. (p. 259)

Another obstacle for many teachers is finding the time to teach in this way, thereby taking time away from what is often a content heavy curriculum. Sperry advises that even though many teachers have this concern, most would recognize that they would be more successful in teaching the main concepts if they could spark the student's interest, show new ways in which the science connected to their daily lives, and how it could be used for meaningful tasks (p. 58).

The Use of Frameworks. When teaching the process or the criteria of how to think critically, it is important to guide the students by the use of some sort of framework. There are many different styles and approaches mentioned in the literature, and I will outline a few of them below (see also Appendix A).

Dawson and Venville (2010) see the use of writing frames as a way for students to write and think individually, that it provides a scaffold to guide them in recording their thoughts, and that the question prompts also require the students to provide evidence and alternative viewpoints (p. 145). Jones et al. echo this notion from their future thinking study and argue that their writing frames (Appendix A – Framework #1) offer "useful prompts to help students identify dimensions of future thinking (the existing situation, relevant trends and drivers, possible and probable futures) and select preferable futures with justification" (p. 703). They also noted that the "framework helped students to link scientific knowledge with creative thinking so that scenario development incorporated an understanding of current trends and drivers rather than guess work or just 'dreaming up' what the future might look like" (p. 705). Thier (2008), also relates a few common frameworks (Appendix A – Framework #2 & #3) that are important in questioning information from different sources and has the students ask questions such as who created the message, does it show bias, what techniques do they use, what is implied or omitted, and is it consistent with the current scientific understanding? (pp. 21-22).

Wolf, Bach and Waitz (2014) used frameworks (Appendix A – Framework #4) to help focus student's attention when reading news articles involving chemistry. They used the framework to help the students visualize and concentrate on the main phenomena in the news story, the causes of the phenomena, and finally the possible consequence (p. 82). Van Allen (1995) furthers the idea of having some visual reference for students and emphasizes that frameworks do not have to be simply written words, but can also be strategy maps and graphic organizers (p. 109). Finally Terry (2012) believes strongly in the use of various case studies to act as scenario frameworks, guiding students in different methods and levels of thinking along the way.

The Majetic and Pellegrino (2014) study, goes in depth with the use of scaffolding and frameworks to help their class of non-science majors have a better understanding of science and especially how science is portrayed in the media. They exposed their students to news stories and asked them to think critically on a number of different levels including identifying the main scientific ideas, examining its accuracy, and assessing the potential for bias (p. 108). To help their students and to give them the proper skills to be able to do this, they had a number of assignments that built on one another. In the first assignment students read a short scientific paper that was associated with a topic that had already been discussed in class. They were then given several questions (Appendix A – Framework #5) that encouraged the students to look at each section in isolation and focused more on understanding the kinds of details necessary for a good paper, and less on mastering the actual content. The students then discussed the paper together in small groups, which allowed them "to test out their answers safely among their peers before presenting them to a larger audience or the professor" (pp. 109-110). After the safety of the small group discussion, there was a full-class discussion that addressed each question and the instructor build on their ideas, encouraged questions on the content, and spend time helping

student interpret graphical information. The authors found that this discussion encouraged further thinking and often lead to "questions about statistics, experimental methods, styles of writing, graphical displays, and the underlying biology of the study organisms, all of which help to build student understanding of the nature of science and formal scientific writing" (p. 110). Only after the discussion were the students then asked to write a synopsis of the paper addressing five questions (Appendix A – Framework #6) including what was the major objective, how do the authors interpret this research, and does this paper do a good job of achieving its objectives, why or why not? (p. 110).

To build on the skills of the students, the next assignment in the course was for the students to take a newspaper article found by the instructor and, with the help of an instruction session by the Librarians, to find the original source material as well as supporting scientific material. The students then prepared another synopsis similar to the first one, but with extra questions where they were asked "to assess whether the news story accurately depicts the findings of the research and explain why or why not" (p. 110), and to consider if the news story could have "benefitted from the additional information found in this new research paper and to provide a rationale for their answers" (p. 111). Overall Majetic and Pellegrino found that using these approaches and frameworks provided a 'low-pressure' environment that made the articles less intimidating and required the students to critically think as they reflected on the article's scientific accurately through fact-checking and improved literacy skills.

Conclusion

After reviewing the literature on critical thinking in the high school science classroom there is clear evidence of the importance of teaching critical thinking skills. Students need the information and skills to develop the habit of asking questions so that they can start making their

own decisions and value judgments. To help the students make personal connections and stay engaged, it is important to connect these critical thinking skills to not only their own lives, or individual background knowledge, but also to society at large. Finally, it is important that teachers take the time to model these ways of thinking and allow the students opportunities, using scaffolding and frameworks, to help them practice using these skills and ultimately thinking for themselves.

Chapter 3: The Project

Overview

Our current reality is that information is everywhere. Unfortunately this it is not always accurate nor reliable and students need to think for themselves, decipher the good science from the bad, and always continue to ask questions. In this chapter I present three activities; the first activity is a weekly routine that will introduce YouTube videos on a scientific topic throughout the course, while the other two are single classroom activities. The second activity encourages students to examine articles for scientific evidence and teaches them what questions to ask, while the third activity allows students to find and evaluate their own research articles on a scientific topic and have a discussion with their peers on an online discussion forum (refer to Figure 1). Each of these activities are meant to help incorporate larger scientific ideas, connect the students to new research as well as issues that science may have in society, and develop skills to help them question science from everyday sources. It is my hope that these activities will "promote the development of a critical, scientifically and technologically literate citizenry capable of understanding [Science, Technology, Society and Environment (STSE)] issues, empowered to make informed and responsible decisions, and able to act upon those decisions" (Pedretti, 2003, p. 219).

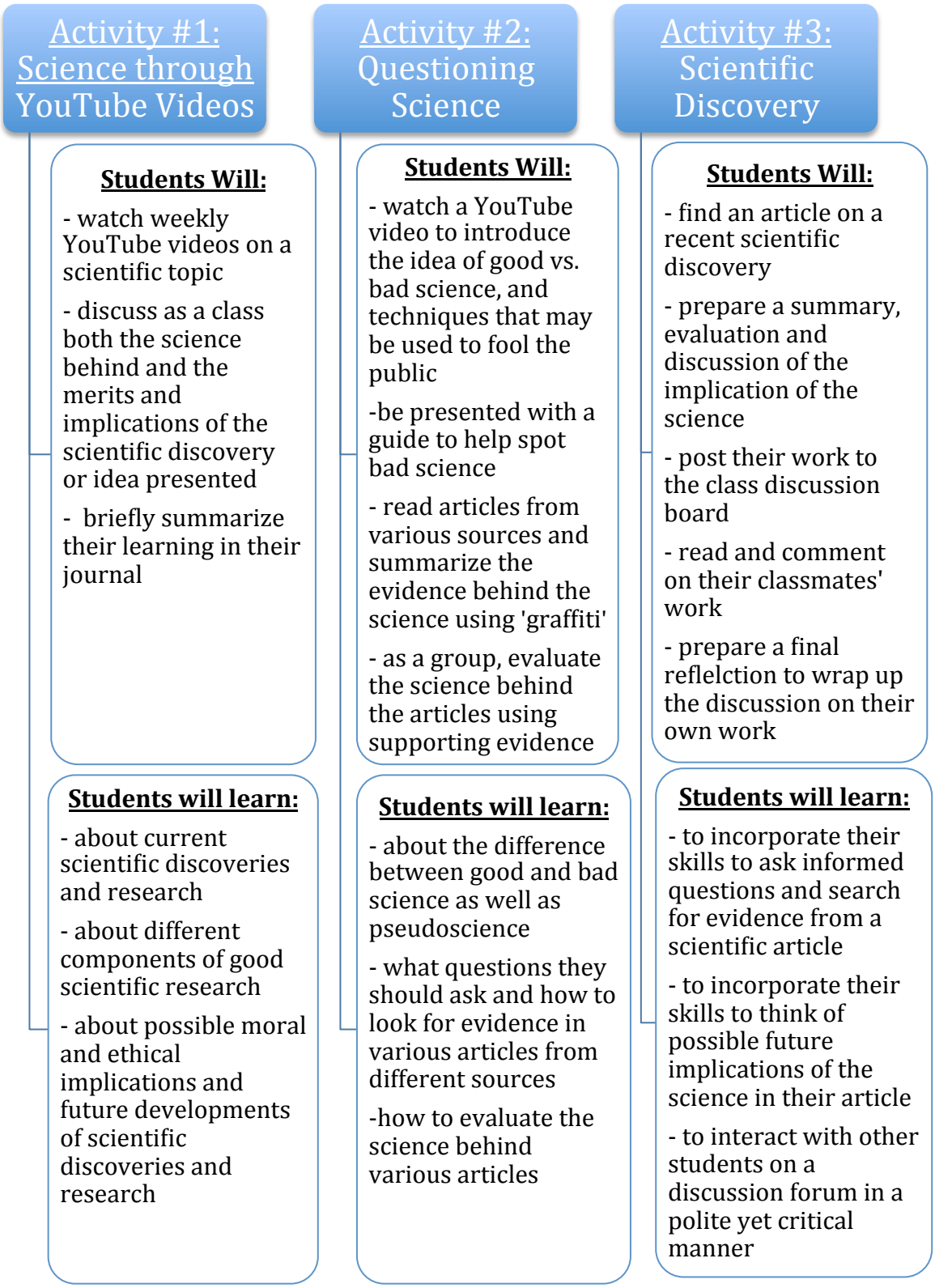


Figure 1. Outline of activities and student learning

The first activity involves incorporating recent science discoveries by watching short videos once a week and having brief discussions about them. In the second activity, students will learn how to ask informed questions about scientific research, especially when it is presented in the media, and will learn what evidence and techniques to be aware of. In the third activity, students will make use of an online discussion board to write a brief synopsis and evaluation on a scientific topic, ask guiding questions in response to their classmates' posts as well as add to the discussion of their classmates' work.

These routines and activities are presented in such a way as to take up the least amount of time possible in an upper level science course since these courses are often very content heavy and do not have a lot of extra time for such activities. These activities will all be presented on a variety of scientific topics, not grounded in any one subject individually (ex. chemistry, biology, etc), with the intention to encourage students to realize the interconnectedness of the sciences and so that they may be used in a variety of classrooms.

I will begin this chapter by offering my intentions for the activities; relating them to the IRPs of various upper level science courses in British Columbia including Chemistry 11/12, Physics 11/12, Biology 11/12, Earth Science 11/Geology 12, and Science and Technology 11. I will then describe each activity providing an explanation of the activity, a rationale tied to the research, and finally I will discuss teaching and learning challenges that may be associated with each activity that I have experienced as a high school science teacher. For the third activity I will also share my experiences with the creation of a class website that supports a discussion board, and share some of the pedagogical rewards and challenges that one can experience when using this technology in the classroom.

Intention

When designing these activities, I wanted to find a way of encouraging my students to think critically, bring recent scientific discoveries and ideas into my classroom, as well as have my students see the big picture and the important connection between science and society. I also wanted to develop in my students increased scientific literacy so that they can be informed consumers of science, especially in relation to what they see and hear in the media, and later become informed citizens and decision makers who can impact future policies.

The activities have been designed in a social constructivist learning style so that students can continue to construct their understanding, first together and then later on their own, however it will be first demonstrated by the teacher. For example in the first activity the teacher will model asking questions by creating a discussion around YouTube videos, in the second activity the students will work together to ask questions around the evidence presented in various articles, and then finally in the third activity, students will work on their own and ask their own questions. By scaffolding the activities in this way and by continuing to come back to the same ideas in a recursive fashion, it encourages the students to gradually become more comfortable with the ideas and thinking on their own in this manner.

These activities or approaches are also designed to be transferrable to any upper level science course. The connection of science and society is an important component in all upper level sciences, even though it is one that is often missed as teachers try to cover all of the other prescribed learning outcomes. The Chemistry 11/12, Physics 11/12, Biology 11/12, Earth Science 11/Geology 12, and Science and Technology 11 Integrated Resource Package (IRP) all have similar language that state:

> School science programs [are] planned to develop scientifically literate students [and to] provide experiences that

- develop the capacity to think critically
- encourage students to examine the impact of scientific knowledge on their lives, society, and the environment
- cultivate students' appreciation of the scientific endeavour and their potential to contribute to it (British Columbia Ministry of Education, 2006, p. 3)

By having students think critically and question the science that they see and hear about every day, they will learn how to ask informed questions and how to come up with their own interpretations about what society should do with science and technology, and where they as individuals might guide it in the future.

Activity #1: Science through YouTube Videos

My first activity involves a routine of showing weekly videos, mostly via YouTube in my classroom. These videos will be on a variety of scientific topics, either new discoveries or concepts and ideas that are designed to encourage students to think about something in a new way. The underlying goal is to help them "interpret science and technology as complex socially embedded enterprises" (Pedretti, 2003, p. 219). These short three to ten minute videos will be presented at the beginning of class one day a week. So that these videos are on current scientific thought and discoveries, they will mostly be found through various YouTube channels that I will outline later on in this section.

After each video the students will have a short discussion about the videos with the teacher choosing what aspect of the video or questions to discuss as a class. Each of these discussions will be brief and will take a different view on the topic, helping to guide students into what questions to ask about the science or possible implications on society, and will act as a way of introducing some of the ideas that will be built upon in the other two activities. For example these discussions can delve deeper into the scientific method and how the experiment was set up,

about the particular viewpoint or concept of the research, or implications of where this new discovery might take us into the future or what the next step might be.

Some of these discussions can also be very controversial, especially with respect to political values or ethical implications of certain research. In order to facilitate this type of discussion, it is important to know your students and to have created a safe environment. I often wait until a few weeks into the course before starting these types of discussions, and I will usually ease into these discussions with activities such as using a value line or four corners where students choose and stand where they feel comfortable about a certain topic and then students volunteer to explain why they put themselves where they did. After students have tried this a few times, they are more likely to share their thoughts on controversial issues in the future. This method of dealing with controversial topics also encourages the ideas from Klosterman *et al*. (2012) about offering multiple perspectives and having students take a position and to support that position with evidence (p. 66). This idea will also be strengthened and further built upon in the next two activities.

Once the discussion is complete, students will be asked to write a brief summary of what they learned or found interesting from the video and discussion in a journal. Students will continue to add to their journal after each video presentation and so it will act as record of their journey and ideas throughout the course. Furthermore, it may act as a potential resource when they are trying to choose which topic they would like to pursue further during activity three.

Rationale for YouTube and discussion activity. As mentioned in the IRPs, the science curriculum encourages students to become scientifically literate by:

- actively gaining knowledge, skills, and attitudes that provide the basis for sound and ethical problem solving and decision making
- developing an understanding of the place of science in society and history and its relationship to other disciplines

- making informed and responsible decisions about themselves, their homes, workplaces, and the global community (British Columbia Ministry of Education, 2006, p. 3)

By giving students an opportunity to see current information and ideas offered from multiple perspectives around various scientific topics, especially potentially controversial topics, students will have the opportunity to question what they already know and see the world in a new way. They will also become more aware that while scientific discoveries impact society and our everyday life, society also impacts the direction and implementation of science and potential future scientific discoveries. Overall, the goal of this activity is to introduce new scientific discoveries and ideas to the students, to help them find something that they may be interested in which they may choose to build upon in activity three, and most importantly, to encourage students to think!

Resources. There are many great scientific videos that are appropriate for a wide range of classrooms. Using YouTube to find these videos is a very effective tool since there are many content creators that reliably produce videos on a variety of current scientific topics from different perspectives. Some create weekly longer videos (~10 minutes) but many of them create almost daily shorter videos on an assortment of topics so it is straightforward to find something current that will work in the classroom. Below I have outlined some of my favourite sources for these videos.

SciShow/Scishow Space.

https://www.youtube.com/channel/UCZYTClx2T1of7BRZ86-8fow

https://www.youtube.com/user/scishowspace

SciShow is a combination resource that talks about Science news and discoveries, and its subchannel SciShow Space discusses new discoveries in space. The shows are

created and often hosted by Hank Green and vary in length with ~3 minutes shows offered daily, and a weekly show which delves deeper into a topic and is ~10 minutes. Additionally, they also often offer a review show of all of the important scientific discoveries from the past week. Overall the videos are excellent at explaining scientific ideas and discoveries in a manner that is easily understood by students.

DNews.

https://www.youtube.com/user/DNewsChannel

Another great resource is DNews, which is created by the TestTube network, an offshoot of the Discovery Network. DNews presents ~2-3 minute videos twice daily. The hosts are entertaining, as well as interested and informed on the particular field of science presented in each video. A negative aspect of these videos is that they are often funded by corporations and often promote and link advertisements to the science they are presenting, however, this can offer an interesting discussion with students about possible biases in the media.

VSauce.

https://www.youtube.com/user/Vsauce/featured

VSauce presents longer (~10 minute) videos that often make interesting connections to science, history, society and general ideas that help students think about their world in a new way. The host, Michael Stevens, does an excellent job at entertaining his audience and creating a wonderful web of ideas. While not all of his videos are entrenched in science, a few of them are wonderful additions to the classroom discussion.

Asap Science.

https://www.youtube.com/user/AsapSCIENCE/featured

The Asap Science videos are a weekly video series created by Mitchell Moffit and Gregory Brown. They are always entertaining and offer white board animations to explain everyday science topics in a very easy to understand way.

Periodic Videos.

https://www.youtube.com/user/periodicvideos/featured

http://www.periodicvideos.com/

These videos are created by the Chemistry department at the University of Nottingham who have been creating videos for many years. In fact, they now have a video for every element on the periodic table and continue to create weekly videos about science news, chemical reactions, and historic information that are all Chemistry related. While their videos are very informative, they are not always as entertaining as a typical high school student demands, and the science can be at a level above what the students may understand, but in general it is a great resource for chemistry.

Practitioner Reflection. An advantage to this routine is that it does not take much class time to implement. In the past I have shown these videos at the end of a Friday class, but often we would not have much time for the video or any meaningful discussion. By placing these videos at the start of class and making them a focus, there is time to have some discussion, while still only taking ~15 min away from the regular lesson once a week. Also, in my experience, I found that it was often nice to start the week off with one of these videos as I found that students would often ask me something or make a comment about them a day of two later, while if I

waited until Friday to show them, they would often forget about it over the weekend and no further discussion would take place.

Logistic/Challenges. One challenge is the need to constantly be on the lookout for new videos as it is important to have the most up-to-date videos possible so that it might connect into what the students would have potentially already heard from other media sources. By subscribing to some of the YouTube channels I mentioned above, there are many options of various videos with differing ideas and viewpoints to choose from. One disadvantage and one of the realities of YouTube videos is that they are often difficult to find again as they can be removed at any moment. This can be overcome by using one of the many programs out there to download the videos from YouTube directly for use in the classroom. The other caution to be aware of when using YouTube is that anyone can post a YouTube video so it is important to preview and use your teacher judgment when finding appropriate videos that will present reliable information.

Activity #2: Questioning Science, What does *good* Science look like

The goals of this activity are to highlight what to look for in 'good' science, and to point out some of the 'red flags' and ploys/tactics that may be used to help sway an individual or misrepresent the science involved. This activity has several parts and should take one or two class periods. To introduce the discussion on good/bad science and the idea of pseudoscience, students will first watch a few YouTube videos. There are many great videos that could work well to introduce this topic, and below I have highlighted two options that could be used together or individually.

Video resources.

inFact: 5 Ways to Tell Science from Pseudoscience.

https://www.youtube.com/watch?v=e3SLiQFdKnA&index=2&list=PLKrudY2-oOMB4mJZiJ11sBsMDizoxnS51

The first is a 3 minute video where the host, Brian Dunning, goes through five techniques or 'red flags' to watch out for that are often used to misrepresent science and to sell products. This ranges from the idea of something being advertised as being 'natural' and therefore good for you, to the idea of 'ancient knowledge' vs. scientific testing, and the idea of a 'miracle drug'. This video is presented in an easy to understand way with many great examples and works well as an opener to get students thinking.

TEDTalks: Ben Goldacre: Battling Bad Science.

https://www.youtube.com/watch?v=h4MhbkWJzKk&list=PLKrudY2-oOMB4mJZiJ11sBsMDizoxnS51

The next video is ~15 minute from TEDTalks and offers a more scientific spin on bad science. It goes into depth about how science 'should' be conducted (ie. sample size, controls, blind sampling) and mentions some of the practices that are often used by large pharmaceutical companies to fool doctors and the general public into believing their claims are true. There are many great points that are made during this video, and while there is a lot of new information presented here for the students, many of the ideas will be further scaffolded in the next component of the activity.

Discussion. The next part of the lesson will address some of the aspects of good science mentioned in the above videos so that students will have an idea of what sort of things they should be looking for and what questions they should be asking. To help summarize some of the information and to help further guide the discussion, Figure 2. A rough guide to spotting bad science (Brunning, 2014), will be presented to the class, and each component discussed. Some

of these components include being aware of possible conflict of interest or bias behind research, the difference between correlation and causation, the importance of a large sample size and the use of control groups, and the idea that all data should be shown and not simply ‘cherry-picked’ results where only the data that agrees with the hypothesis/interpretation is highlighted.

Figure 2. A rough guide to spotting bad science (Brunning, 2014)

Articles. For the next part of the activity, students will be divided into groups and each group presented with a short article. Some of these articles will be from everyday sources such as newspapers or magazines, some will come from scientific magazines (ex. Science, Discover), some will be abstracts from scientific papers, and others will be from more casual sources such as blogs. These articles can be on a variety of topics and should be chosen so that they represent both good and bad examples of science, scientific research, and layman's scientific interpretations.

The students will start off the activity by reading their short article. They will then have a minute or two to do a 'graffiti' activity where they quickly write down on a central piece of paper one piece of evidence that supports the science in the article and one question that they have about it. The students will then rotate to the next article station and do the same thing repeating this process until they have addressed all the articles.

Once the students have all rotated through the different article stations, they should have an idea of the different levels of scientific knowledge that can be represented in each different style of article. Their next job will be working with their group using the peer-graffiti to summarize the quality of the science in the article, backing up their claims with evidence from the article. To focus their work, they will be provided with a basic framework of guiding questions (refer to Appendix B, Student Handout #1). I created this framework with the influence of many of the frameworks that I described in Chapter 2 (refer to Appendix A) as well as by using the ideas already discussed with the class in Figure 2. Once complete, the students will then briefly present their evaluation and validity/reliability of the science to the class.

Rationale for Questioning Science Activity. The rationale of this activity was to have students analyze scientific information from a variety of sources and to practice questioning

those sources of information. In the previous activity, media (via YouTube videos) was used to present different scientific ideas. In this activity, the media itself is examined. As Klosterman *et al*. (2012) mentions, teachers must start "teaching **about** mass media—not just teaching **through** mass media" (p. 53). It is my hope that after this lesson, my students will be able to "view data with a scientist's skeptical eye - especially now that so much un-refereed information is online, in advertising, and in other media sources" (Thier, 2008, p. 20).

Thier (2008) also mentions that "a healthy skepticism requires a delicate balance between being open to new ideas and also being doubtful of claims for which there is no clear and convincing evidence" (pp. 20-21). The emphasis on the need for evidence is clear in this activity by both having the students search for it in the graffiti activity, as well as the need to use this evidence to back up their claims in their final evaluation.

By having the students discuss their article in small groups, there should be less pressure on the students as individuals and allows the students "to test out their answers safely among their peers before presenting them to a larger audience" (Majetic & Pellegrino, 2014, pp. 109-110). Also, by using their classmates' graffiti to guide and reassure their thoughts, this may help to further ease their possible anxiety as well as offering up different points of view for them to consider.

Logistic/Challenges. For this activity, the teacher may choose to have the various articles on a variety of topics, or could offer the same topic presented from different viewpoints and with varying amounts of evidence to support it. Tolbert (2011) encourages the latter idea as he believes that "teachers should use multiple and even conflicting texts to encourage students to find and reflect on the main ideas of a variety of texts around the same topic" (p. 259). This can lead into the main challenge that the teacher can encounter - the difficulty of finding articles that

represent the various examples. While bad science and pseudoscience is rampant in this day and age, it can be hard to find suitable, easy to read examples to use in the classroom. An example of common pseudoscience that may be a good topic to use in the classroom is the recent measles outbreak and the anti-vaccination movement.

This activity may not be adequately covered in a single lesson, so it may be prudent to have the students start the graffiti part of the activity on the first day, and have them finish the final article analysis the next day. By having the students at least read their first article (which will also be the article they will analyze later) on the first day, and coming back to it on the second, it will give them some time to think about it as well as providing them the opportunity of seeing it with fresh eyes the second time.

In regards to the presentation of the final task to the class, this could be done with a group representative presenting to the class as a whole, or else it could be done using the jigsaw method of creating expert groups where each member of the group would be required to present it to a member of each of the other groups. In this way all students are responsible for the content, as well as the process of presenting would be less stressful as they are only presenting in front of a few students instead of to the entire class.

Activity #3: Scientific Discovery

The third activity is a culmination of the other two wherein students will, outside of class time, have to find a recent article (either from a scientific magazine, newspaper, blog, etc.), or a video such as the ones that have recently been shown in class, about a scientific discovery. They will also be required to find at least one additional reference to back up their discovery and to be able to reference them using proper APA formatting. Once they have found the topic article and

references, they will write a three-paragraph summary of their topic (refer to Appendix B and Figure 3).

In the first paragraph, students will be required to summarize the discovery and the science in their article. This will be a brief written synopsis and will most likely be general in content as we may not have covered the topic in greater detail within the class. The second paragraph is where students will make use of what we have learned in the previous two activities and will evaluate the science within the article. They should question both how the research was conducted as well as potential bias, 'cherry-picking' data, etc., backing up their assertion with evidence and stating if this seems like good scientific research, what could have made it better, if they agree with the conclusions drawn from it, etc. In the final paragraph, students will add their own personal reflection about the research by addressing what they think of the discovery, what they think the future of this research might be, how it might affect society, potential moral or ethical implications that might need to be considered, etc. Finally they must end their writing with at least two discussion questions to help spark future discussion amongst their classmates.

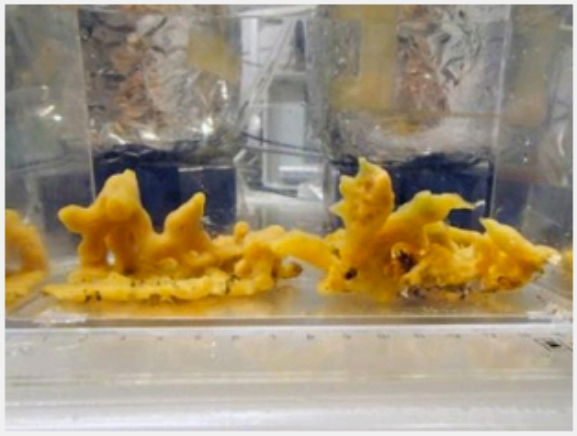
Heather Anderson

Does life need oxygen?

Source: Theory on origin of animals challenged: some animals need extremely little oxygen. (1014, February 17). Retrieved March 21, 2014, from http://www.sciencedaily.com/releases/2014/02/140217161110.htm

Published: February 17, 2014

Normally science has always said that life could not have formed without high levels of oxygen being present, however a species of sponge commonly found at the bottom of deep fjord near Denmark contradicts this. This sponge was tested to see how low the oxygen levels could be where it was still able to breath and grow. From this research it appears that the sponge was still able to continue these life processes with oxygen levels as low as 0.5% of the normal level of oxygen in our atmosphere. This sea sponge is being used as an example of early life and suggest that there wouldn't have had to been a large percent of oxygen in our atmosphere for life to have evolved.



It is not exactly clear how they performed the low oxygen tests, or how may sponges were used in the experiment. It is also unclear how long the sponges were exposed to these low amounts of oxygen and therefore if they would have been able to survive long-term under these conditions.

This discovery opens up the question of what is actually needed to sustain life and many questions about how we may have evolved. It is believed that we evolved at the same time as an increase in oxygen in our atmosphere but are the two necessarily connected? Right now we are also looking for signs of life on other planets but if we are not sure of what factors are necessary and which ones aren't, are we going to miss some of these signs?

Figure 3. Screenshot of example project post

The students will be given one week to prepare the above synopsis and evaluation and to upload it to our class discussion board. The online discussion board was created as a feature of

my class website where students can post their work and then other students have a place to add comments. I will speak more about these features and the website creation process in the next section. After that first week the students are given one additional week to complete the discussion part of the project where they will make their comments on their fellow classmates' work. When choosing whose work to comment on, the students are advised to not simply comment on their friends' work, but to find something that they are interested in, and to also try to comment on those students who do not already have a lot of comments. Students are encouraged to make these comments meaningful and add to the conversation. In order to help the students get started, they will be given some suggested response prompts (Figure 4), which may help them to come up with possible ideas.

Some suggested response prompts:

- This made me think about…
- I wonder why …
- I wish I understood why…
- This post is relevant because…
- I was reminded that…
- Your writing made me form an opinion about…
- This is important because…
- Another thing to consider is…
- I can relate to this because…
- I don't understand…
- I found myself wondering…
- Your writing made me think that we should …

Figure 4. Suggested Response Prompts

Practitioner Reflection: Website Creation. Before this project was presented to the class, I made my own classroom website and discussion board. I could have had the students presenting and discussing this project face-to-face, but I wanted to take the least amount of class time as possible and I wanted it to work with the student's own time table where they could choose when they worked on the project. I also wanted to encourage the discussion over several days where students would have time to think about what they wanted to say without feeling embarrassed about speaking up in front of their classmates. As Dunn and Peet (2010) mention in their article, "research shows that blended learning (the use of the Internet to enhance standard

face-to-face classes) is an effective method of teaching" (p. 420). I also wanted to try something new as these days, students are ahead of the curve and are "technology-savvy and techno-dependent. Constant communication contact is their way of life. Failing to utilize this as a channel for learning is a waste" (Dunn & Peet, 2010, p.420).

Even though I was aware of this information, I had not spent the time to create a website before now. One of the reasons why is because I was unsure about how to get started and I didn't want to have another responsibility that I would have to maintain. I think I am not alone with these obstacles as Ertmer *et al* (2012) noted that "the strongest barriers preventing other teachers from using technology were their existing attitudes and beliefs toward technology, as well as their current levels of knowledge and skills" (p. 423) but that they also noted that "teachers' own beliefs and attitudes about the relevance of technology to students' learning were perceived as having the biggest impact on their success" (p.423). Most teacher websites are abandoned after a few years, but I now believe that if the students use them often and with purpose, they can become very powerful tools.

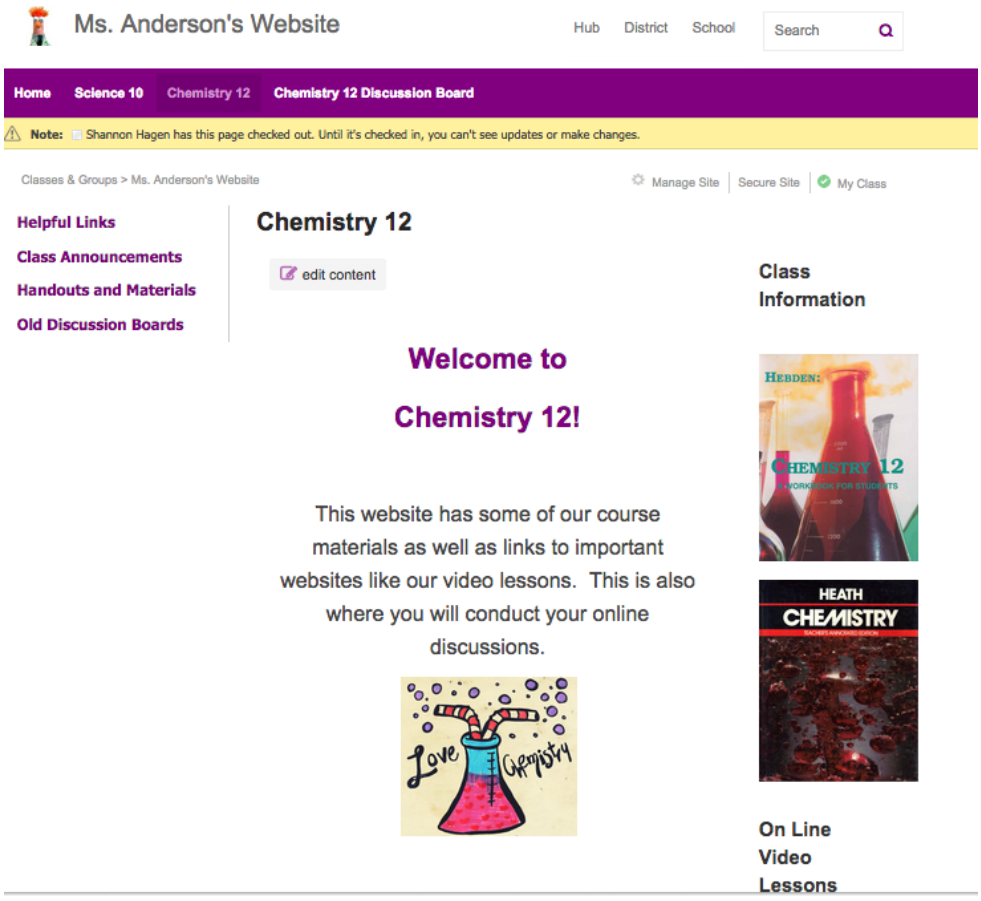


Figure 5. A screenshot of my chemistry 12 website

The basis of my actual website is through SharePoint (Refer to Figure 5). Other online web services are also available, but I choose to use SharePoint because my district supports it which meant there was already a template in place, as well as a place to house my website. As an added benefit I could also get help form my school's technology teacher, which I found invaluable in the process. The other very important factor was that this website is private; students have to login to access it and all of the information is stored by the school district and not by a third party.

The creation of the website was not a simple process since I had to work out some of the kinks along the way. But once it was created there was very little work for me to do besides monitoring the discussion feature. The discussion board is an option of the SharePoint website

and since each student needs to first login to my site, when they make a post it automatically records and posts their name as well as the date and time of their contributions.

In order to get my students used to my website, they were encouraged to use it throughout the course as it also housed extra copies of the note packages and resources packs, useful study links, as well as all of the links to the online video lessons which they were to use whenever they missed a class. In addition, the information and criteria for the Science Discovery project was solely found on the website, which students were guided through when the activity was first presented and encouraged to review periodically throughout the project.

Rationale for Science Discovery Project. The main purpose of this activity was to link together all of the information and skills that students had learned over the past activities; from learning the aspects that make good research, how to evaluate good science from the bad, but also taking it further and connecting it to society and the big picture. One of the main differences in this activity was that the students had to take an active role and find/choose the source themselves. As Klosterman *et al* (2012) state if

> One of the goals of issues-based education is to prepare students for future encounters with new issues as they arise, [then] a key element of that preparation ought to be developing practices associated with finding new media sources, not just reading and interpreting media sources (p. 71).

This also aligns with the upper level science IRPs which state that becoming scientifically literate "involves finding, gathering, assessing, and communicating information using electronic means" (British Columbia Ministry of Education, 2006, p. 10). It also reinforces the need for students to look past simply the information presented and to see the larger picture as scientific literacy "involves a critical examination and understanding of the ethical and social issues" (p. 10).

Finally, by using the online discussion board, students were given a platform where they were the ones in charge of their product as well as the direction that the discussion went and they became the experts on their topic. As Sperry (2012) recounts "teachers [need] to think of their students, rather than themselves, as the most effective vehicle for delivering key concepts and understanding to each other" (p. 58).

Practitioner Reflection.

Science Discovery Project. While completing this project with my class, I found a number of challenges that I had not initially thought of, and some things I would like to emphasize and improve on in the future. The first was the importance of teaching students some basic writing skills and not to simply assume that they had received all of these from their English teachers. For example, it is now a priority for the science department at my school to teach students proper APA referencing as we found they were not being taught this in their other courses. This will now begin for all students in Science 9, and be reinforced by some sort of research project in all science courses thereafter. Since this is a new departmental initiative, my students had not been given instruction before, however in the future they will only have to be given some basic instruction before their project is undertaken.

I found that the student summary of the articles in general were interesting but I really loved reading the third paragraphs where students had to give their own opinion and ask questions of their classmates. Students had some very interesting ideas and suggestions, talked about some ethical issues (like animal testing and when it might be appropriate), and also brought in other knowledge about world economies, questions about hygiene practices, sleep schedules, etc. I was also very impressed when some responding students would ask the student something that they didn't understand from the original post, and the original student would

supply answers with additional information that answered the question and in the process showed their learning as they were now the ‘experts’ in that area.

The online discussion board also offered a way for students who may not normally interact with one another a reason to do so. This was especially evident as I had two chemistry classes doing this project so students often commented with students from the other class. I also believe that it was important that students got to choose what they wrote about and which topics they responded to. Some students clearly choose to comment on their friend’s work, but it was clear that many chose to comment on something that they were passionate about or found very interesting.

By having students do three comments (plus one wrap up comment on their own), I found that all but one student had other students commenting on their work. Most students did comment though a few did not get around to it, but that may have been because of how close the deadline was to Christmas (Thursday to Thursday of the last week of classes before the break). For the original post only a very few students did not participate, and these were students who often have difficulty completing their work so I do not believe that it was a problem of access to computers, especially since our school has many computers available for student use.

Two pairs of students did their research on the same/similar topics but luckily each gave a different spin to it. Students were first asked to check online to see what topics had already been covered so that they would choose something else, but that may be hard when there were 50+ topics being used. Next time I would have students sign up and tell me so that I know what topics are already covered. This would also help students better deal with time management and encourage them to start thinking about the project earlier.

Technology. While there were many wonderful outcomes of this project, there were also frustrations, most of which had to do with technology. We had a week to start our initial post, but some students reported that they couldn't use the new discussion board I had made (I had archived the one from the semester before). Eventually the technology teacher and I discovered how to give students permission to access the new one through some back door methods but it caused some frustration on the part of the students. There were also problems with students posting pictures, which caused some students frustration, however that problem was later fixed and is now much easier.

Once the initial posts were completed, students had a week to do follow-up comments. Unfortunately a day after I had told them to get started, I learned that the whole system would be down for maintenance and updating the very next day, and that even if it were possible to post anything, it would be deleted. The updating was supposed to take a week, however it took closer to two, and once it finally started up (and after several confirmations that the system was indeed working), we finally got to the project, however what was supposed to take two weeks, took closer to four. The new system is more straightforward, especially with how to post and add pictures, so hopefully this was a one-time frustration and things will be better in the future.

Conclusion

By using these three activities of showing YouTube videos and having class discussions, analyzing media and looking for scientific evidence behind its claims, and finally having students find their own articles to analyze and participate in their own discussion, my students will have a better recognition of the interconnectedness of the science disciplines, an understanding of the role they, as well as society at large, can play in shaping science and its endeavors, and they will be able to question science they hear and see around them. This will

also meet the requirements of the upper level science IRPs which state that students need to "acquire and analyze information, to reason and communicate, to make informed decisions, and to understand and use information and communications technology" as the "[d]evelopment of these skills is important for students in their education, their future careers, and their everyday lives" (British Columbia Ministry of Education, 2006, p. 10). By focusing on and revisiting these things in small ways throughout the course, it will create an awareness, as well as a appreciation for the intricacies of science and will help students to be better prepared to question and think about science in a beneficial way throughout their lives.

In the final chapter of this project, I will present how this project was developed and how the other courses in this Master of Education program influenced me along the way. I will also share how this project has influenced me and my teaching, and what I think might be the future of it in my classroom, but also in the classroom of some of my colleagues and potentially other educators. Finally, I will conclude with a few recommendations for other educators who might want to take on a similar project.

Chapter 4: Reflection

Introduction

In this section I will discuss the evolution of my project and how it developed through my learning from the other courses in my Masters program into what it has become today. I will also consider possible future development for my project and my own pedagogical growth as a teacher, as well as what impact this project may have, both on my school and my school district. Finally, I will end with some recommendations for anyone who is considering teaching critical thinking and scientific literacy through the media in his or her own classroom.

My Initial Understanding

I have always had a passion for Science and an appreciation for how the world works and the interconnections of it all. I have wanted to pass on this appreciation to my students but I realized that that was not what I was doing. This Masters of Education program caused me to step back and really evaluate what I think is important and what knowledge and skills I want my students to take with them when they complete my course and are venturing out into the world on their own. I quickly realized that it was less about the facts and concepts that I wanted them to remember, but rather about an appreciation and awareness of science and the knowledge to question the science around them.

This project started off as a way of helping my students with their critical thinking skills, but I quickly realized that is a big task and one that needed to be anchored in something more tangible. I realized that although not all of my students would be entering into scientific vocations, they would continue to learn of scientific advancements, and need to interpret and evaluate scientific claims and arguments presented in the media. I then took my idea of critical

thinking and placed in in the realm of questioning this everyday science that they may encounter so that they could make their own judgments.

Further Development of the Project

Several of the courses I took as part of this masters program helped to shape the future direction of this project, including the course on technology as a pedagogical tool. I had always wanted to make a class website but had not gotten around to actually doing it and I was not exactly sure what I wanted it to look like. Having the option to choose what I wanted to investigate and pursue it in the course lead me to finding two of my colleagues in the program that wanted to try it out as well, and us becoming some of the initial participants of using SharePoint to make teacher websites in our school. I am very grateful that I got to try this out with my colleagues as we could bounce ideas off of one another especially since each of us had slightly different ideas about what we wanted. One of the features of SharePoint that I was not initially interested in was the discussion board. I had initially dismissed it until one of my colleagues thought they might try it out and described how they were thinking of using it. Their idea intrigued me and I realized how much I had learned from and enjoyed having the online discussions through Moodle in some of our other courses and that there was no reason it couldn't work in my high school science course. This lead to experimenting with the feature and eventually to the final scientific discovery project that I have included in this project.

Once I took my environmental education course, I was also introduced to the idea of Science, Technology, Society and Environment (STSE) whose goal it is to help students get involved and see the big picture of how science and technology affect the world and how the world can affect science and technology. Reading and learning about STSE and how it could be used in the classroom stimulated me to add this topic as a focus. By having my students deal

with societal, ethical and other issues around science they realize that science is not always as black and white as we often make it seem. It also encourages their critical thinking skills and helps them to further see how they themselves can choose to interact with science and shape its future once they have left school, either as scientists themselves, or purely as informed citizens.

This then completed the idea for my project – to teach my students skills that would help them to think critically about science that they may hear in the media and to help discover what part they play in shaping its future. This, however, still left the idea of how I was actually going to go about it. Teaching high school science courses often does not leave much room for other activities. It would be nice to have these activities in a general science course such as Science 10, but with its government exam, there is not enough time for extras. Instead I decided to try it out with my grade 12 Chemistry students as they are the ones that will soon be leaving us, and I wanted them to start thinking about the larger world out there that they would soon be joining.

My project

In order to fit this project into limited time frames, I tried to design it as a collection of overarching ideas that would penetrate the course as a whole, but that would mostly work in the background. Since this material does not necessarily line up with any individual content in the curriculum it is appropriate to have it run throughout the course. By presenting short videos on current scientific topics and having a discussion about either the science behind the topic or the impact that it might have on society, it gets the students thinking in new ways about new topics. By having the students evaluate actual scientific articles, blogs, newspapers, etc. they can learn what to look for and how to question a source and its information. Finally, by tying these skills together and having them find their own sources related to something that interests them and then having an online discussion about it, independent of the teacher, it lets them practice

becoming scientifically literate and engaged citizens. This approach provides students with opportunities to practice the skills they have learned in a potentially real world way, while having meaningful discussion with their peers.

Future Developments of the Project

Now that I have had the opportunity to try out this project with my class, I would like to continue to develop it further. One of the possible future developments may be to increase the use of the discussion board. I believe that it could fit very nicely into the journaling done during the first YouTube video activity. After each discussion students write down a brief summary of what they learned or found interesting or even further questions that they have, and there is no reason why this could not be done as a comment on the online discussion board. This way students could then go back and read all of the comments left by their fellow students and have a better perspective of differing points of view and ideas that their peers may have shared, and the potential to have further ongoing discussions. This could even be done right in the classroom assuming that students had, and were able to connect to the internet through their cell phones, though that may be harder if there are students without smartphones or if the technology is not in place in the school to support it.

I would also like to see the development of this project, or one similar, into the lower grades. I believe that it would fit extremely well in a grade 9 Science class that may have more time to spend on this. If this project could be integrated somehow throughout the grades, being added upon each year, then the students would come into grade 12 with further practiced skills and they could take the project idea even further.

Another way that this project could be taken further is by having a fourth activity where students could choose a topic or idea and create an inquiry based project. I was lucky enough

recently to enter into a grade 4/5 class and see them work on their own inquiry project. Every student in grade 4/5 worked on their own project all day for an entire week and were in charge of all aspects of the project and of the questions they wanted answered. I believe that it would be very interesting to see the results if a similar model were used in middle or high schools, where students could be given the opportunity to delve deeper into a single topic and further use their critical thinking and questioning skills.

Future for the School/District

I feel very fortunate to have had the opportunity to enter into this Master's program with many of my colleagues, both from the district, as well as from my school, and even my department. I feel like it brought us closer together both within the science department, between the science departments at the two high schools, as well as between different departments at my own school. It was very interesting to learn what other teachers were doing in their classrooms and I believe one of the greatest learning opportunities that this Master's program provided was for us to learn from each other. This was especially true when other members of the program were interested in similar research, such as with the creation of the website, or when another colleague was also interested in STSE. By learning together and offering up different points of view it both encouraged our individual professional development and helped us to grow as a team, hopefully offering up further opportunities to share and work together in the future. It is my hope that some of my colleagues will want to incorporate parts of my project into their classes just as I am hoping to incorporate some of the wonderful things that they have been trying into mine.

Recommendations

For anyone who would like to bring a project like this into their own class, I have a few recommendations that may be helpful, including starting small, finding technological support within your school/district and letting the students take charge.

First off, I would recommend starting small. Before diving into this project as a whole, try bringing in some YouTube videos or other information of scientific discoveries and advancements that may be prevalent in the media on a regular basis. Once the logistics of that have been worked out, start bringing in further questioning skills and other aspects of the project.

Another piece of the project was of course the technology needed to find and show the videos as well as the creation and implementation of the discussion board. In order for technology to work well in the classroom, you need to be adequately supported. Find out who the technology person is in your school or district and work closely with them to achieve your goals. I found that mine was invaluable in many different aspects of the project and it all would have been much more frustrating without their help and guidance.

My final recommendation is simply to relax and take a step back. I know that I find it hard to step back and let my students take over, but I found that as the course went on, and they became more familiar with the routines and skills, they needed less direction in both the in-class discussions, as well as in the other activities. This is especially true with the final activity of the science discovery project where great results were achieved by the students with limited teacher involvement.

Closing Thoughts

I believe that, as educators, we are responsible for making sure that our students have the skills they need to navigate the world. By increasing student's scientific literacy and critical thinking skills we are equipping them to become informed citizens who can take an active role in shaping the future, both for us and for them. This graduate program and my experiences within it have furthered my own abilities to support these literacy and thinking skills with my own students and I encourage other educators to explore new ways to do the same.

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Appendix A: - Critical Thinking Frameworks:

Framework #1:

Jones et al. (2012) futures thinking conceptual framework (p. 692).

Understanding the current situation: *What happens now, and why?*

Identifying key trends: *How does what happen now differ from what happened in the past, and why? Are the changes desirable? Who benefits? Who loses?*

Analyzing relevant drivers: *Are some of the changes (trends) related? What are the underlying causes for these changes?*

Developing scenarios of possible and probable futures: *Are current trends and drivers likely to persist? How might they affect the future? What might change them?*

Selecting, with justification, one or more preferable future(s): *What do you want to happen in the future and why?*

Framework #2

Their and Daviss' (2002) Key Media Literacy Questions (cited in Their, 2008, pp. 21-22)

1. Who created this message? Why are they sending it?

2. What techniques are used to attract my attention?

3. What kinds of words are being used? Is the writer using words to stir emotion?

4. What lifestyles, points of view, and values are represented in the message?

5. How might different people understand this message differently from me?

6. What is implied? Read between the lines

7. What is omitted from the message?

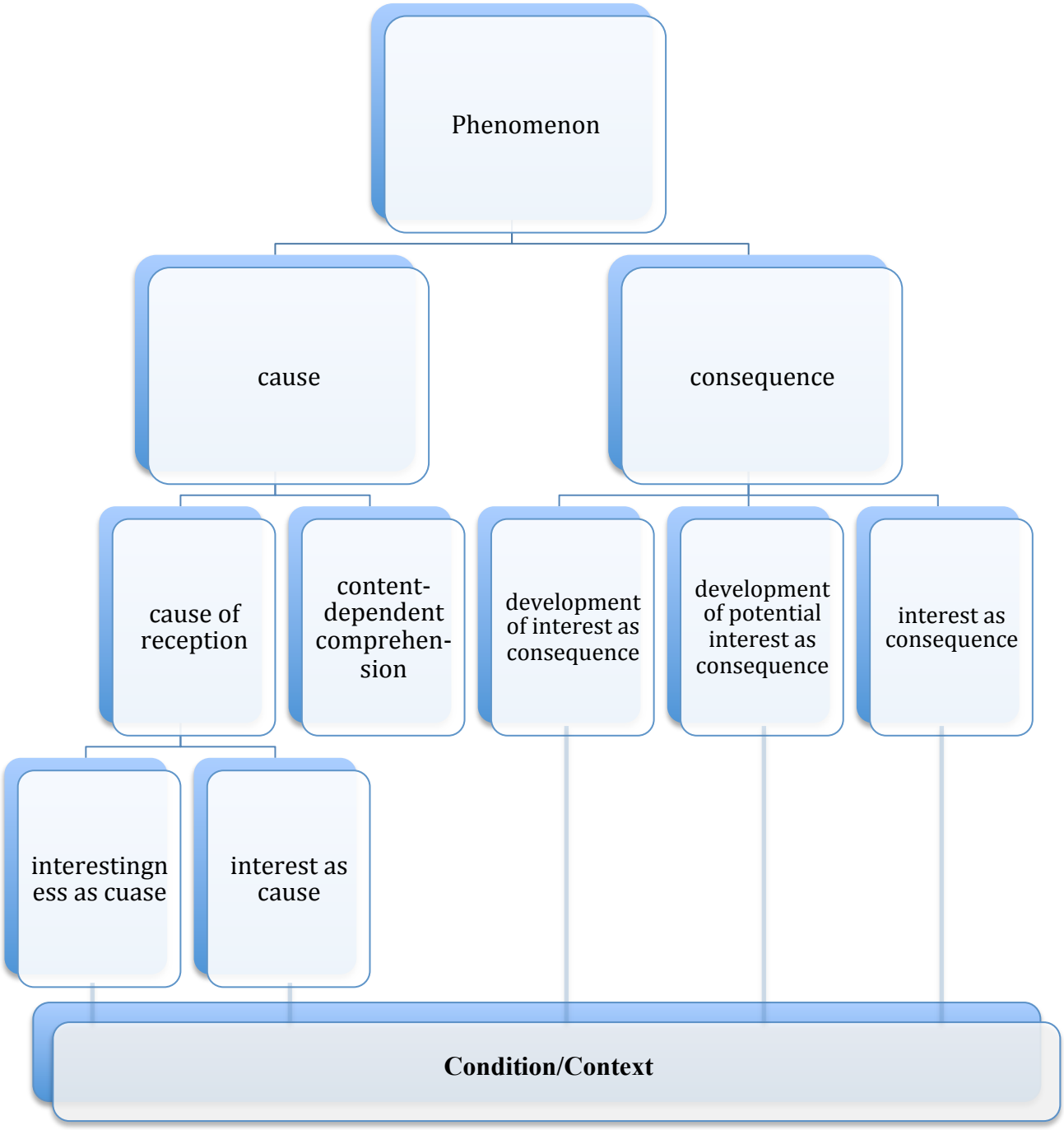
Framework #3

Bartz's (2002) CRITIC framework (pp. 43-44)

CRITIC		
C	Claims	(Spell out the claim)
R	Role of the claimant	(Who is making the claim and what's in it for them?)
I	Information backing the claim	(What evidence is there to support the claim?)
T	Test	(Can we design an adequate test?)
I	Independent agreement	(Has an unbiased source carried out an independent test that agreed with the claim?)
C	Cause proposed	(What is described as a causal explanation for the claim? Is it consistent with current scientific understanding?)

Framework #4

Adapted from Wolf, Bach and Waitz's (2014) Analysis structure for the interview (p. 79)



Framework #5

Majetic and Pellgrino's (2014) Questions assigned to support in-class discussion of assigned scientific paper (p. 110)

Questions Assigned to Support In-Class Discussion of Assigned Scientific Paper

Question 1: Look at the Abstract at the very beginning of the paper – what is the point of this paragraph?

Question 2: Flip to the Discussion and look at the first two paragraphs, which usually summarize the most important points of the paper. What do these authors say are the most important things you should take away form this paper? Does this match up with what the Abstract says?

Question 3: Take a look at the figured and tables in the Results section. Can you describe what these tell the reader? Does the text in the Results section match the contents of the figured and tables?

Question 4: The first section of the paper is the Introduction, which usually describes the background information that the authors use to frame their research. The last few paragraphs in the Introduction usually outline the questions or hypotheses that the researchers intend to answered in the paper, and why. Can you summarize these

things in your own words? Do your findings match what the Discussion and the Abstract say?

Question 5: Finally, take a look at the Methods section. This is usually the most technical section of the paper. Are there any ideas in this section that make sense to you? Any ideas that do not? Come with any questions that you might have.

Framework #6

Majetic and Pellgrino's (2014) questions assigned to support synopsis of a scientific article (pp. 110-111)

Questions to Support Assigned Synopsis of Scientific Paper

What was the major objective of this research, and why was it undertaken?

What was the research methodology?

What were the major results of this research (with a focus on figures and tables)?

How do the authors interpret this research, particularly in regards to environmental issues?

And finally, in your opinion, does this paper do a good job of achieving its objectives and presenting them to an audience, and why or why not?

[Additional Questions for News Article Assignment Synopsis]

… whether the news story accurately depicts the findings of the research and explain why or why not.

… whether the news story would have benefitted from the additional information found in this new research paper and to provide a rationale for [your] answers.

Appendix B: Student Handouts:

Student Handout #1: Article evaluation student framework

Article Title: Article Author: Article Source:	
1) Is it clear who created this message/research?	
2) Do you think they have any other motivation/bias? Was there any clear conflict of interests?	
3) What techniques are used to attract my attention? Are they trying to stir emotion?	
4) Do they explain the research methodology? Does it follow a proper scientific method? a) What was their sample size? b) Did they use a control group? c) Was blind testing used? d) Did they (or someone else) replicate their results? e) Is this article from a peer reviewed source?	
5) Does it appear that they may have omitted anything? If so what?	
6) Does there appear to be any other obvious possible causes for the reported outcome?	
7) Was there something that they could have done to further support the science behind the research?	
Overall how well do you feel this article did in presenting accurate and unbiased science?	

Student Handout #2: Science topic discussion criteria

Science Topic Discussion:

Once this term you will find an interesting article, video, etc about some new discovery in science and you will post this in our Discussion board on our website. In your post you must include the following:

Description:

Paragraph 1: **Synopsis** (Minimum 5 sentences)

- The main points of the article
- A brief summary of the science discussed

Paragraph 2: **Evaluation** (Minimum 3-5 sentences)

- A Critical analysis of the source of the article's information or of the science used. In such an analysis you might address some of the following questions : Do they tell you where they got the data? Is it clear who conducted the research, and whether or not they may have had a conflict of interest? Were there controls used in the experiment? Might there have been another interpretation of the data or another cause? How this discovery relates to past work/how is it different/unique from past knowledge?

Paragraph 3: **Personal Reflection:** (Minimum 5 sentences)

- Your point of view (eg. What do you think about the issue? Do you have further questions that weren't answered? What could this discovery mean for the future? How do you think this discovery could help/harm society?)
- Make sure to end with at least 2 discussion questions – your job as the "expert" is to spark discussion in the comments of your post.

You must also:

- ➔ You must have at least **two** different relevant sources and they must be referenced in proper APA format
- ➔ You must include at least one photo/video related to the discovery.

Note that these are the minimum requirements
and if you would like a higher grade (A range), you must do more!

General Guidelines:

- ➔ Make sure to make good use of evidence from the article
- ➔ And DO NOT PLAGIARIZE, quote and reference where needed but make sure to use your OWN words!
- ➔ Try to spell everything correctly and with proper grammar
- ➔ Do not use curse words, inappropriate language, or chat language

In addition to posting about your discovery, you must also comment on the discoveries of at least **three** of your classmates. When deciding whom to comment on, try to find something that peaks your interest but also try to comment on people who don't already have a lot of comments.

Your comments:

→ Should be ~3-5 sentences in length

→ Write meaningful comments that add to the conversation and show why you think the project is exciting/controversial/important

→ Support your opinions and ideas with explanation/evidence (explain **why** you agree or disagree)

→ Be respectful of the opinions and work of others

→ Use proper grammar/spelling