A CASE STUDY ON THE IMPACT OF USING A MOOC FOR HIGH SCHOOL SCIENCE AND MATHEMATICS INDEPENDENT STUDY COURSES

by

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ABSTRACT

This case study involves five students, all high school seniors, who elected to enroll in a Massive Open Online Course (MOOC) as part of their independent study courses during the final trimester of the 2016 school year. The students chose their fields of study and the primary topics they intended to investigate. The topics extended beyond the school's science and mathematics curriculum, thus, the students were pursuing these courses for enrichment purposes. Five instruments were used to measure how much students were interacting with the MOOC and the value of the MOOC in terms of learning: pre-course interviews, post-course interviews, mid-course surveys, post-course surveys, and the Brief Electricity & Magnetism Assessment concept inventory. When considering the primary research question, "What impact can MOOCs have in high school independent-study enrichment courses?", there is evidence in this case study to suggest that MOOCs can have a positive impact, therefore, can be used to guide and support students seeking such enrichment opportunities.

INTRODUCTION AND BACKGROUND

Setting

Sewickley Academy is a private, independent, coeducational day school founded in 1838. Located in Sewickley, Pennsylvania, a suburb on the Ohio River northwest of Pittsburgh, the school serves approximately 700 students from pre-school through twelfth grades. All students are college-bound with a variety of interests and passions. Students come from a wide area of communities with often vastly different socioeconomic statuses (Sewickley, n.d.).

A small group of students engage in independent study each year. These students typically are seeking enrichment in subjects that extend beyond the course offering in the Sewickley Academy Senior School. The independent study coursework is traditionally designed by the student and minimally managed by a sponsoring teacher. The students schedule regular meeting times with the sponsoring teacher to offer aid and guidance as seen fit. Grades are typically earned according to the goals and assessments chosen by the student.

Problem

Students seeking enrichment through independent study courses often have limited opportunities for guided instruction that provide structure, motivation, and high-quality assessment.

Purpose

One of the joys of teaching high school science and mathematics is that students often approach me to ask about learning topics that are beyond our curriculum. These

students are frequently so excited to learn more, it is hard to contain my own enthusiasm for their curiosity and sense of inquiry. I sometimes recommend students to develop a plan to complete an independent study course that is entirely self-directed. Unfortunately, these enrichment experiences fail more than they succeed. Often the goals of the courses change or are abandoned when students become distracted when the work gets challenging or they just get so far off track from their original plan that they end up completing very little, and thus, learning very little. Recently I have suggested that students use the growing number of free online courses from platforms such as EdX or Coursera as guides in independent studies. The Massive Open Online Course (MOOC) is intended to provide them guidance in the content and structure of their studies so that they have an authentic experience studying the subjects that interest them. The purpose of this case study was to investigate the impact and effectiveness of using MOOCs in independent study enrichment courses in science and mathematics.

Research Questions

The research questions I intended to answer were:

Primary Question of Inquiry:

- What impact can MOOCs have in high school independent-study enrichment courses?

Sub-questions of Inquiry:

- How can MOOCs provide guidance and structure to the independent-study course?

- How do MOOCs affect students' attitudes and motivations in an independent-study course?
- What value do the tools and resources in MOOCs add to the independent-study course?

CONCEPTUAL FRAMEWORK

Establishing the Importance of Innovation in Independent Studies

The MOOC has sparked considerable debate among educators, particularly in higher education (Moe, 2014). It should not be surprising that students also have differing attitudes and preconceptions about how well such a format can help them learn. Understanding what these feelings and attitudes are before, during, and after the course should provide some insight into how effective the course is in promoting learning for a variety of students.

Students' predispositions for independent learning have influences on their success in MOOCs. Measuring and understanding students' intrinsic motivations and attitudes about learning is important for predicting the value of participating in a MOOC. Liu, Kang, and McElroy address the general thoughts and feeling of students at a few points during the MOOC completion (Liu, Kang, & McElroy, 2015). The authors attempted to measure and categorize how students perceive their experience with the MOOC and how their attitudes change throughout the MOOC. They also attempted to identify the parts of the MOOC that students perceived as the most and least helpful. The study was able to show that the participants had different experiences depending on their background and prior learning. The important takeaway is the conclusion that students

with a strong motivation for independent learning were more likely to have positive experiences as well as complete the course (Liu, 2015). As students progress through a MOOC, it may be possible to predict their success depending on their attitudes and motivations.

Najafi, Evans, and Federico presented several recommendations for effectively integrating MOOCs into high school courses (Najafi, Evans, & Federico, 2014). Using a MOOC as a supplementary part of a high school course (blended mode) and using the MOOC as a stand-alone class produces substantial differences in outcomes (Najafi, 2014). Comparisons between these modes revealed that results were mixed on two main assessments. The MOOC-only students appeared to be better at online assessments, while the blended-mode students were more likely to stay on-track and complete the MOOC (Najafi, 2014). The students in this study were described as "highly-motivated students taking an advanced economics course" (Najafi, 2014, p. 310). This is important because most students involved in high school independent studies would likely be described in a similar manner. Students are likely to be highly engaged and excited about the MOOC at the start, but these attitudes will change as the course progresses (Najafi, 2014). There is much to be optimistic about regarding the use of MOOCs in high schools. It is worth noting here that Najafi, Evans, and Federico finished their report by concluding that: "The results of our study are promising regarding integrating MOOCs in school-based courses in a self-study manner." (Najafi, 2014, p. 319) The importance of this statement on my research is obvious. There is substantial value in determining if students can effectively utilize a MOOC in their independent studies.

The Commonwealth of Pennsylvania has begun its own research on the best practices in independent studies (Education, 2016). The recent report issued by the state identifies the need for guidance on the process and structure of independent studies. The Department of Education highlights the fact that most schools that offer such extracurricular work do so only for students who need minimal supervision. The state also notes that independent studies "may be more challenging than a traditional course because a student is operating without peer support and is responsible for staying on track without teacher reminders or outlines" (Education, 2016, p. 2). Much of what is discussed in the *Toolkit on Independent Study Programs* describes the experiences that motivates this case study. No legal documents have been produced to guide independent study. The Commonwealth of PA appears to be in the process of reviewing best practices and hopes to have clearer guidelines in the coming years (Education, 2016). This gives sufficient relevance to conducting this case study at this particular moment. The results of which may even provide some support and guidance to support the state and other schools.

A Theoretical Basis for Considering Online Learning in Independent Studies

Education can be defined in a variety of ways. Participating in a community of learners in order to promote the collective good is one way of defining education. Another way would emphasize the importance of gaining knowledge and skills to become more marketable in the global workforce. MOOCs are new enough to education that their value is still being determined (Liyanagunawardena, Adams, & Williams, 2013). The implementation of any new practice in schools usually involves a theoretical

basis to advance learning. Using a MOOC in high school independent studies should also have similar theoretical support.

Many schools have sought ways to offer advanced enrichment courses for what is usually a small group of interested students. Michael Horn specifically emphasizes the value of using MOOCs as a way of providing Advanced Placement courses as independent learning experiences for high school students (Horn, 2014). This is critical to my classroom research project because the participating students fit neatly into this description. Educators and policymakers alike have promoted the use of online learning and in some cases passing laws requiring students to engage in such courses (Horn, 2014). Clearly some people have understood the potential impact of open online learning in high schools.

A surprising number of researchers have been interested in the impact of MOOCs on the general public as well as students in formal schools (Liyanagunawardena, 2013). In an article titled *MOOCs: A systematic study of the published literature 2008-2012*, Liyanagunawardena, Adams, and Williams revealed nearly everything published in the first four years of the MOOC phenomena. This study provides a clear definition for MOOC after analyzing many studies on the subject. It also provides a framework for the variety of ways in which MOOCs are used all over the world. There are clear directions for growth in research on MOOCs, primarily centered around the strategies and motivations that students use in completing MOOCs (Liyanagunawardena, 2013). Successful completions of MOOCs have led directly to positive outcomes such as extended learning communities that last well beyond the course's end

(Liyanagunawardena, 2013). Finding the motivational techniques that instructors and students use has the greatest potential in impacting the future of MOOCs (Liyanagunawardena, 2013). This viewpoint is essential for using the results of this case study to successfully implement a MOOC in high school classrooms.

The United States Department of Education completed a comprehensive meta-analysis on research in online learning in 2010 prior to the development of the modern MOOC. This meta-analysis is significant in that some of its findings answer some basic questions about the effectiveness of online learning. For example, this study was able to show that students in online environments performed better or on par with students in traditional face-to-face instruction, regardless of content or methods used (Means et al., 2010). The authors were also quick to point out that the research on K-12 students was quite limited and therefore, they cautioned that applying the findings to such students is limited in scope (Means et al., 2010). Nevertheless, such a meta-analysis establishes the importance of further research in using online platforms such as MOOCs in high schools.

Literature to Guide Methodologies

An important aspect of learning is making social connections with peers in the pursuit of solving problems that promote the good of all. The MOOC has a unique challenge because it often connects people electronically while simultaneously separating those same people physically. High school students in independent studies will be challenged to do something entirely different than traditional schooling. They will need to learn some difficult subject matter without the face-to-face interactions they would typically get from a traditional classroom. This does not mean that MOOCs do not

provide social interaction, but offer new types of social learning. A proper case study needs to collect data about how the MOOC impacts the students' learning experience with a keen eye on these students' adjustments to the social changes. Furthermore, it will need to track how the students' feelings change throughout the course.

Another important aspect of learning is empowering students to choose their own path to success. Students who are more invested in the choice of methods for learning and assessment are more likely to sustain their learning in the future (Glasser, 1998). The evolution of the MOOC has given students more freedom to choose a learning method that they enjoy and with which they can remain engaged. Despite being in their infancy, MOOCs have evolved quickly and they seem as though they will remain a popular choice for learning among students all over the world. It seems that a logical next step will be increasingly offering MOOCs to high school students as an option for meeting educational goals.

Andrew Hill conducted an expansive study of social learning in MOOCs in his doctoral dissertation titled: *Social learning in massive open online courses: An analysis of pedagogical implications and students' learning experiences*. The author did a two-part study, first surveying all of the social tools being used in MOOCs and second conducting interviews with students engaged in using each of those tools. The author cites the importance of social engagement in learning and how MOOCs have advantages and disadvantages in social learning (Hill, 2015). Ultimately the author decides that his study lacks the necessary measures of reliability and validity needed to make strong recommendations in practice. Nonetheless, he was able to identify a clear need to

address a major aspect of pedagogical methods that appeared to be lacking in the design of MOOCs (Hill, 2015). The coding techniques in the interview process were a valuable tool for analyzing interview transcripts. The author coded statements that reflected the utility and value in social learning.

North, Richardson, and North argue that MOOCs should have "limited adoption" at this stage in the development of distance learning because they fell short of the type of learning that higher education expects from its students (North, Richardson, & North, 2014). In their attempt to measure the value of MOOCs against the variety of online learning options in colleges and universities, the authors point out that the progression of using online technologies to deliver content to students has made the MOOC a "logical outcome of the ongoing evolution of distance learning" (North, 2014, p. 69). The goal of their study was to attempt to measure where MOOCs fell short and where they rose above traditional distance learning courses. The authors concluded that MOOCs are here to stay as integral part of higher education (North, 2014). Obviously, interested parties want to know the positive and negative impacts a MOOC will have on students. North, Richardson, & North provide a framework for asking meaningful questions in the broader context of online and distance learning.

Montana State University graduate, Christian Mills, evaluated the effectiveness of a growing program of online courses for math and science students in a high school in Wyoming. The author wanted to determine if the program was producing its intended outcomes of improving learning opportunities for a variety of reasons. Some students were seeking credit recovery for a failed traditional course, some were homebound, while

others were seeking flexibility in their schedules (Mills, 2011). The online courses were created by a third party and were managed by teachers at the school attended by the students. Mills summarized his finding this way:

> Online education has the potential to bring quality education to those students who may not be able to find it in a traditional classroom. By helping these students to receive their education despite varying circumstances, we will be helping to reduce the dropout rate as well as encouraging students to complete their education, and perhaps go to college. (Mills, 2011, p. 47)

Developing a strong alternative to traditional schooling using online courses is not trivial and is quite important to many practitioners (Mills, 2011). It is important to note that the author did not have a specific treatment because this research was mostly a descriptive study. My classroom research project on implementing MOOCs in independent studies represents a similar type of case study. Mills' school's online and virtual education initiative was a kind of treatment meant to address the needs of students who were unlikely to finish their education or unwilling to take on valuable enrichment experiences (Mills, 2011). My case study involved similar measurements and analyses. Mills was interested in measuring the current state of affairs so that he could direct the program towards reaching its goals. He used six different methods of gathering data. The student exit survey provided data about the students' perceptions and attitudes about their online coursework. Similarly, the student post-survey interview probed students' affective experience with virtual education. The NWEA MAP test was used to quantitatively measure students' growth on standardized course objectives. Course grades were used to compare traditional courses to online. Teacher and facilitator interviews were used to evaluate the online experience of those in charge of managing specific aspects of the

courses. Enrollment information from the school district was used to evaluate changes in enrollment since the start of the online program. Each of these was necessary to collect the appropriate evidence to answer the research questions. Many of the methods described later in my case study's methodology section mimic this approach. Mills also frequently mentioned the importance of triangulating data to create a meaningful perspective on which he could base his conclusions (Mills, 2011). He was appropriately cautious in noting that the sample size limited the usefulness of the conclusions (Mills, 2011). Here again, my research is similar due to the small number of students involved the case study.

There were several key findings of Mills' study. The author organized each finding according the original research questions. For example, the first sub-question asked: *What are the benefits of online education for high school students?* An important conclusion related to this question was that most of the students appreciated the ability to work at one's own pace on a flexible time schedule. The second sub-question asked: *How do student grades in online classes compare to those in traditional classrooms?* The author concluded that MAP test scores and final course grades were similar to those in traditional classes, but some students clearly benefited much more than others. The third sub-question asked: *What are student attitudes and concerns toward online education?* The big take-away here was that three-fourths of the students were willing to take another online class and would recommend online coursework to their peers. The fourth sub-question asked: *What are the impacts of online education on teachers?* The teachers found the Teacher Scored Test portion of the online courses to be burdensome

and time-consuming. Finally, the overall question of the study asked: *What is the impact of online education on student achievement at the high school level?* The author reached a conclusion on this question that favored hybrid-type courses in the future that could better meet the goals of all students (Mills, 2011). His methods were good enough to reveal some important trends that could guide the school's program forward. The students requested more interaction, the teachers remarked that some questions were easier, and the MAP test was not aligned with the virtual courses (Mills, 2011). My research described in the following pages serves as a good follow-up study that specifically targets students who are engaged in enrichment experiences. Using Mills' research as model could help in improving validity and reliability.

Interviews and surveys are important instruments in collecting data about the impact of using MOOCs, however, there is substantial value in measuring the gains in learning in a way that characterizes the overall impact of the intervention. Four of the five students scheduled to take part in my case study will be attempting to learn important concepts in electricity and magnetism. A few diagnostic inventories exist that can be used to measure the conceptual growth of students in learning electricity and magnetism. One such instrument is the Brief Electricity and Magnetism Assessment (BEMA) developed by physics educators Chabay, Sherwood, and Reif. This instrument was used in my research to establish some level of effectiveness in meeting learning goals with the MOOC.

Concept inventories (CIs) are useful tools for educators in measuring learning gains. Julie Libarkin explains the importance of such assessments by stating that "CIs

can be used to diagnose areas of conceptual difficulty prior to instruction, and evaluate changes in conceptual understanding related to a specific intervention" (Libarkin, 2008, p. 1). Obviously, the sample size in my case study limits the strength of the conclusions drawn, but the students' gains on pre-test and post-test are derived from a valid and reliable instrument. This is important because establishing validity and reliability is the most important aspect of choosing the proper tool for measuring growth in science courses (Libarkin, 2008).

The BEMA has been modified and improved over a decade in order to provide the most valid and reliable instrument that is easy to administer in a variety of settings, including MOOCs and independent studies. Ding, Chabay, Sherwood, and Beichner describe the BEMA as a tool "to measure students' qualitative understanding and retention of basic concepts in electricity and magnetism" (Ding, Chabay, Sherwood, & Beichner, 2006, p. 1). They go on to describe statistical methods for testing the validity and reliability of each item as well as the entire assessment using students at Carnegie Mellon University and North Carolina State University. Ultimately, the authors were able to clearly establish that the "BEMA is a reliable test with adequate discriminatory power" (Ding, 2006, p. 6). The assessment currently holds a gold star rating in validation—the highest level of research validity (Kohlmyer, et al., 2009). The BEMA is a useful instrument in measuring students' prior knowledge and their growth in conceptual understanding following the MOOC.

Choosing the proper instruments and administering them in the best ways is a topic that has been thoroughly studied by Lovelace and Brickman (Lovelace &

Brickman, 2013). The authors describe successes and pitfalls of using interviews, surveys, and inventories, specifically in measuring students' attitudes about learning. The authors show that the best choice for measuring engagement are Likert-scale questions similar to instruments designed and tested by Gasiewski et al. (Gasiewski, et al., 2012). Lovelace and Brickman also describe the importance of choosing the right tool in measuring motivation such as the Likert-style questionnaire presented by Bryan, Glynn, and Kittleson (Bryan, Glynn, & Kittleson, 2011). Measuring students' attitudes can be especially challenging. Lovelace and Brickman also suggest that a Likert-style assessment such as the Colorado Learning Attitudes about Science Survey (Semsar et al., 2011) can be an effective way of capturing students' attitudes about learning at a particular moment in the course. Each of these items can serve as excellent models in choosing questions that probe students' engagement, motivation, and attitude in the hopes of answering the research questions in my classroom research project.

Literature That Frames the General Impact of MOOCs in Education

There are many yet-to-be-pioneered methods of using MOOCs in education. The reasons for doing so may be guided by a theoretical framework, but some uses may be so unique that no such theory exists. Colleges have been working for decades on how to best address the growing number students needing remedial coursework (Jiang, Williams, Warschauer, He, & O'Dowd, 2014). Inspired by the use of online learning in remedial college courses, Jiang, Williams, Warschauer, He, and O'Dowd published a study in which they investigated the impact of using a MOOC as a preparation course for students entering biology in their freshman year in college. It is hard to imagine that the first

MOOC creators considered using a MOOC in this way in the early days of course development. Some of the students in this study were given the incentive to complete a MOOC by offering them prerequisite enrollment despite lacking the traditional credentials. Effectively, they offered students a remedial course at no cost to the student. These students were more likely to finish the MOOC and, as a result, were more likely to finish their first year in a STEM major compared to students in traditional remedial courses (Jiang, 2014). This is relevant, because it mentions a specific motivation that leads to student success. Perhaps all students using a MOOC may benefit from a similar motivational technique. The authors of this study concluded that MOOCs are an effective means of closing the achievement gap between prepared and underprepared students in STEM majors (Jiang, 2014). Students in the future may be seeking independent studies and enrichment because they are preparing to tackle some difficult academic challenges in college. Understanding how to guide their development with a MOOC could be an important part of their success.

Without a widespread and coherent understanding of what MOOCs are and what they do for students, it is not surprising that opinions vary widely about the value of MOOCs in education. Robin Moe sought to understand and document collective values in his doctoral dissertation which had as its main objective to probe expert opinions about the socio-cultural impact of MOOCs and contrast these ideas with the formal education systems currently in place (Moe, 2014). He used a Delphi consensus-building structure to elicit ideas while asking the experts to agree or disagree with some statements made that reflect the current sentiments about MOOCs. The experts commented and changed

opinions throughout, revealing some important points about use of MOOCs in a variety of contexts (Moe, 2014). They uncovered ideas about the learning value of MOOCs for individuals as well as the community values of educational systems in general. This study provides a theoretical basis for using a MOOC as a means of productive and disruptive technology in high school independent study courses, while at the same time offering caution to widespread implementation. The author concludes that some MOOCs offer extraordinary experiences that lead to substantial learning and, therefore, schools should be investing time and resources into MOOCs (Moe, 2014). It is fair to say that all educators want students to learn and feel good about their accomplishments. With that said, Moe notes that some people may not be convinced that MOOC students will earn the same respect as those who learned in other contexts (Moe, 2014). This will be important to keep in mind when choosing to implement MOOCs in high schools.

Implication of Conceptual Framework on This Case Study

The Massive Open Online Course is an innovative resource that is evolving quickly. The potential of the MOOC to disrupt learning in a productive way is obvious to anyone who has been an active participant in MOOCs over the past five years. On the other hand, the emphasis on an individual's collection of knowledge and skills without traditional social interaction has left many, including me, wondering if a MOOC can be liberally applied in every aspect of education. People seeking specific knowledge for personal gain have successfully used libraries and experts for centuries. In many ways, the MOOC is just a multimedia reinvention of the non-fiction collection in a library. Learners seek out knowledge based on topics and they learn from experts whose

credentials add quality control to the content being professed. High-speed internet in homes and cafes all over the world has allowed this knowledge to be shared ubiquitously. Moreover, the MOOC has created a two-way workspace where learners can also become teachers through sharing and collaboration of new content. It has not gone unnoticed that MOOCs can bring together students of all ages who are interested in similar concepts. This includes high school students who are looking for enrichment in their coursework by means of an independent study course. My research focuses on those students and the impact that a MOOC can have on their success in such a course.

The articles and papers referenced in the text above have provided three main guideposts in for my classroom research project. The first is simply a background and history of how MOOCs have been used, especially in high schools. The second guidepost is for effectively using data collection tools to measure those items I think most important. Lastly, I am reminded of how the vagueness of results can limit the conclusions that can be drawn from this case study.

Reviewing the history of the MOOC and how it has been implemented in many different situations has given legitimacy to my research questions in this case study. Much more research is still needed to develop a coherent theory for the best use of MOOCs. The future for using a MOOC in high school is promising, but certainly not guaranteed. The research reviewed above shows that students who are dedicated can have excellent results, but only if the right motivators are in place. Having classified my students as highly motivated and self-directed learners prior to engaging in the MOOC, I was interested in discovering what techniques the students use or do not use in keeping

themselves on track. Comparison studies provided me a baseline for expectations. This case study focuses on tracking students' attitudes, motivations, and perceived efficacy.

Conducting interviews was essential for me to produce data that allowed me to track the aforementioned qualities. Surveys allowed me to quantify my coding techniques in the interview with scales typical of a survey. It should be noted that these methods were targeted to the research questions and completely ignore the broader context of what education is and what it should be. I am interested in individual student experiences here, thus my data should not be used to draw conclusions about the collective learning that can take place in a classroom, albeit physical or digital. Since I am interested in individual growth, I needed to use an instrument that can measure the learning of specified concepts. I chose to use the Brief Electricity and Magnetism Assessment because of its well-documented validity and reliability (Ding, 2006) and the historical importance of using a concept inventory in science classrooms (Libarkin, 2008). Each of these methods triangulated into some meaningful information, allowing me to steer the future of using MOOCs in my classrooms.

All research studies have uncertainties and limitations. The best research clearly identifies these uncertainties and limitations. My research is limited in many ways. To name a few: my sample size is small, my subjects are not random, and the interviews only capture a brief moment in the entire progress of the course. Each of the articles reviewed above have similar limitations, but that does not mean they are not useful. I think I can take some large steps forward in guiding my students and my school in how we can best implement MOOCs in future courses. The MOOC is a new and rapidly

evolving tool for learning. I will be better suited to make meaningful changes as needed, because I can recognize the limitations of such research.

This conceptual framework has provided me a clear path to getting the most out of my research. I will use the historical development of MOOCs as a tool in asking the best questions in my interviews and surveys and in coding the responses. The validity and reliability of the BEMA gives me a quantitative cornerstone around which I can establish value in using a MOOC for learning. I am open to drawing conclusions based on limited data, because I understand that the answers to many questions about MOOCs will be elusive. Nonetheless, I believe that I have a carried out a better action research project after reviewing some related literature.

METHODOLOGY

Overview of Treatment

This case study involves five students, all seniors in high school, who elected to enroll in a Massive Open Online Course (MOOC) as part of their independent study courses during the final trimester of the 2016 school year for twelve weeks in March through May. The students chose their fields of study and the primary topics they intended to investigate. The topics extended beyond our school's curriculum, thus, the students were pursuing these courses for enrichment purposes. One student was learning about some advanced mathematics using a MOOC specifically designed for differential equations (https://www.edx.org/course/introduction-differential-equations-bux-math226-1x-0#!). One student was learning advanced physics topics on the level of Advanced Placement (AP) Physics 1 (https://www.edx.org/course/apr-physics-1-challenging-

concepts-davidson-next-phy1apccx), with an emphasis on electricity and magnetism. Three other students were learning calculus-based electricity and magnetism on the level of AP Physics C (https://www.edx.org/course/preparing-ap-physics-c-electricity-georgetownx-phyx152x-0). My main goal in this case study was to investigate how MOOCs can have an impact in high schools where students are seeking enrichment in independent studies. The data and analyses presented in the following pages provide insight into the students' experiences.

Data Collection Methods

To measure how much students were interacting with the MOOC and the value of the MOOC in terms of learning, I used five instruments: pre-course interviews (see Appendix A), post-course interviews (see Appendix B), mid-course surveys (see Appendix C), post-course surveys (see Appendix D), and the Brief Electricity & Magnetism Assessment (BEMA) concept inventory (see Appendix E). The research methodology for this project received an exemption by Montana State University's Institutional Review Board (IRB) and compliance for working with human subjects was maintained. See Appendix F for the IRB exemption. Using targeted questions in the surveys and interviews, I extracted enough information to draw informative conclusions from the case study. The table below summarizes the data collection methodologies (see Table 1).

Table 1
Data Collection Methodologies

Research Questions	Data Collection Methodologies					
	Mid-course Surveys	Post-course Surveys	Pre-course Interviews	Post-course interviews	BEMA Concept Inventory (Pre)	BEMA Concept Inventory (Post)
1. What impact can MOOCs have in high school independent-study enrichment courses?	✔	✔	✔	✔	✔	✔
2. How can MOOCs provide guidance and structure to independent-study course?	✔	✔	✔	✔		
3. How do MOOCs affect students' attitudes and motivations in an independent-study course?	✔	✔	✔	✔		
4. What value do the tools and resources in MOOCs add to the independent-study course?	✔	✔		✔	✔	✔

In a case study involving a small number of students, it was possible to do intensive interviews. I chose to do two interviews so that I could be sure to have comparable data for each student. The goal was to understand how the students engaged with a MOOC and how their perceptions of the experience changed. I decided that interviews and surveys were the best way to capture descriptive data about the students' overall experience. Furthermore, quotes from the interviews were used to support the data collected from the surveys. Lastly, and perhaps most importantly, I needed to measure some level of learning according to the objectives put forth in one of the MOOCs. The BEMA was aligned with the desired outcomes of four of the five MOOCs

and it was simple and easy to administer. Furthermore, it is a well-tested tool used in a variety of classes teaching the same or similar concepts and skills, which added to the validity and reliability. Instrument validity and reliability was also addressed in the Conceptual Framework section.

DATA AND ANALYSIS

Interviews

Each of the five students was interviewed before the MOOC for the purpose of collecting data on the students' expectations and attitudes prior to participation. The interviews were conducted with each student and lasted approximately 15-20 minutes. At the end of the MOOC, the students were interviewed in the same manner to gain deeper insights about their success (or lack thereof) in each aspect of the course.

The questions chosen for the interviews (see Appendices A and B) were targeted to elicit conversation about how the students perceived MOOCs and how they felt about participating in the online courses. The questions probed the students' motivations and level of interest and provided plenty of room for students to offer thoughts that may not been captured in a survey.

With the permission of each student, I audio-recorded each interview using an iPad. The students were given an identification number under which the file was saved. Only I had access to the ID key. During the interviews, I also took notes using a computer in an outline format under each interview question. After the pre-course interview, I reflected on the notes to identify common perceptions and outliers. After the post-course interview, I coded the responses according to four basic themes: motivation,

content, tools, and format. The Motivational Strategies category included comments that were related to students' motivations to learn the content. The Content and Objectives category included comments that were related to students' feelings about the quality and relevance of the course objectives. The Tools and Resources category included comments that were related to students' feelings about the quality of the learning resources provided in the course. The Format and Structure category included comments that were related to students' impressions of the structure and layout of the course. Most comments were coded into more than one category. Each comment was also rated with a +, 0, or – to indicate if the comment was positive, neutral, or negative in regards to the students' feelings or perceptions about the course. Both interviews provided help in understanding the impact the MOOC had on students' abilities to stay motivated toward reaching an academic goal.

The Pre-course Interview

The students were quick to schedule a pre-course interview. I think this was an indication of their excitement about starting the MOOC. In the interviews, the students talked so much that it was somewhat difficult to capture everything they were saying, but I believe I got the most important points. It was also difficult getting the students to answer the specific questions I was asking. I frequently brought them back to the original questions, to be sure I was getting meaningful answers for the research questions. Often the students wanted to talk about students at other schools who have done similar things. I understood that listening to peers shapes their preconceptions, but they often spoke in such ambiguity about the other students' experiences that the information was not helpful

in the interview. With that said, the students recognized that they were not answering my questions and quickly obliged to my requests. I think if I were to do this again, I would give the students the questions in advance of the scheduled meeting. When they appeared for the actual interview, I would ask them the same questions, but I would be willing to ask additional questions depending on their responses.

Overall there were four major patterns of preconceptions that emerged from the five pre-course interviews. A summary of those common preconceptions along with supporting quotes is shown in Table 2.

Table 2
Commons Perceptions That Were Expressed by Students During Pre-course Interviews

Common Perceptions	Student Quote
The students expect the MOOC to be challenging because they think they can't quickly access a teacher if they get stuck.	"I've heard that access to instructors for extra help is difficult."
The students expect there to be plenty of opportunities for self-assessment; a lot of instant feedback.	"I like the idea that it is sort of self-paced. It's sounds like a game. It is easier for me to locate what my mistakes are when I get immediate feedback."
The students like that they will have a structured set of goals and a timeline to keep them focused.	"I like the idea of having a constant sense of where I am and how I am doing in the course. I need that to stay focused and to avoid procrastinating."
The students' ideas of success were mainly expressed as a need to learn enough to feel confident in taking similar future courses in college.	"I will be happy if I am more knowledgeable and confident about the content. I figure, if I can do this, then I can do a lot more in college."

There were not any obvious outliers in the students' comments, but I did notice something that seemed somewhat contradictory to me. Four of the five students said something along the lines of: "The MOOC should help me identify exactly where I am

going wrong if I am stuck. Isn't that the point of regularly placed questions with instant feedback?" Three of those four students also said that they are concerned that they would not be able to quickly access an instructor if they get stuck. It seems that the students understood that MOOCs have features designed to give students feedback in ways that are meant to be like having a teacher in the room. On the other hand, the students did not anticipate how these features would actually work in the course.

After talking with the students, it was clear to me that there was a lot to be learned by everyone in this action research project. Nothing from the body language of the students during the interviews led me to believe any of them was nervous about the MOOC, however, some of the things they said indicated that they had some real concerns about the outcome. The discussions they had with other students who have taken MOOCs have clearly shaped their preconceptions. The students expressed concern about getting stuck without having access to quick help. They liked that the time to completion for each assignment was flexible, but they were slightly stressed about the fixed content and schedule for the whole course. They were all thankful to have this opportunity to pursue an independent course on a topic that interested each of them for various reasons. Having a course from a reputable university was interesting to them and they thought it would give them a good sense of what college courses in their field of interests would be like. The thing that they looked forward to the most was the instant feedback and the ability to easily track their progress.

I was slightly surprised to hear that the students have spent considerable time talking to peers from other schools who have done similar online courses. Nevertheless, I

expected the students to be a little anxious about trying something new, but these were independently motivated students. They have already shown that they are capable of tackling tremendous academic challenges. A MOOC is one way of reaching students in an engaging way. The students and I expected to have varying degrees of success as is expected with any teaching and learning technique.

The Post-Course Interview

The post-course interview provided a unique insight into the students' feelings about the MOOC when all activities had ended. I was sure to ask every question that I intended to ask, and the students happily obliged. Each student seemed quite comfortable talking about their experiences with the MOOC. I think that since they knew well in advance that we would be having such an interview, they spent some time reflecting. I appreciated their openness and honesty during our conversation.

Positive statements about the MOOC were wide-ranging. The most positive thing I noticed in all interviews was how much the students enjoyed trying something new. They were happy that they were able to complete the task. In general, they felt like they learned some things to be used in their future academic careers. All the students noted how the MOOC gave them a clear timeline which helped them stay on track. Each student thanked me for giving them this opportunity. Table 3 below shows a typical student quote for each coding category along with the count of similar positive statements.

Table 3
Post-Course Interview Positive Statements

Category Name	Positive Count	Sample Positive Quote
Content and Objectives	12	"I don't think I could have done all of that stuff on my own. I would have been totally lost without a structure like this. The topics were just too complicated to connect them by myself."
Motivational Strategies	19	"I liked that it pushed me to get things done in a particular order with deadlines."
Format, Structure, and Layout	23	"It was pretty easy to use. The quiz questions made sense if you did them in order. The content was very organized from one topic to the next."
Tools and Resources	4	"The practice questions and quizzes were better than just reading a textbook and checking my answers to problems against the back of the book."

Some students were quick to express the things they did not like about the MOOCs. All students stated that the discussion boards, that were supposed to improve engagement and foster collaboration, failed to do either of those things. One student said, "If I had to change one thing, it would be the discussion boards. I just didn't understand how they were supposed to help." There were also several statements about the challenges with entering responses into the MOOC interface. The students felt like they spent too much time dealing with syntax and rounding errors when they were entering solutions to problems. Some students talked about how they would get distracted by other things on their computer while working on the MOOC. Table 4 below shows a

typical student quote for each coding category along with the count of similar negative statements.

Table 4
Post-Course Interview Negative Statements

Category Name	Negative Count	Sample Negative Quote
Content and Objectives	10	"I didn't have a big project to be proud of. Some other students in the past finished their independent studies with a cool thing to show off."
Motivational Strategies	8	"I'm too easily distracted and can get bored doing the same thing every day."
Format, Structure, and Layout	15	"Sometimes I felt like I wanted to just sit and listen without having to answer so many questions. It sometimes felt like the video lessons got chopped up unnecessarily."
Tools and Resources	8	"The discussion boards are not helpful, but they were suggested as being helpful. I thought they were useless."

After coding each of the seventy-seven distinct responses from the interviews, I rated each in terms of its positivity. I did this to quantify students' satisfaction in each category for the purpose of answering the research sub-questions. Positive statements received a score of +1, neutral statements received a score of 0, and negative statements received a score of -1. A summary of the counts of statements receiving positive, neutral, and negative scores is shown in Figure 1 below. Only the Tools and Resources category acquired more negative comments than positive. This is mostly due to the unanimous dislike of the discussion boards.

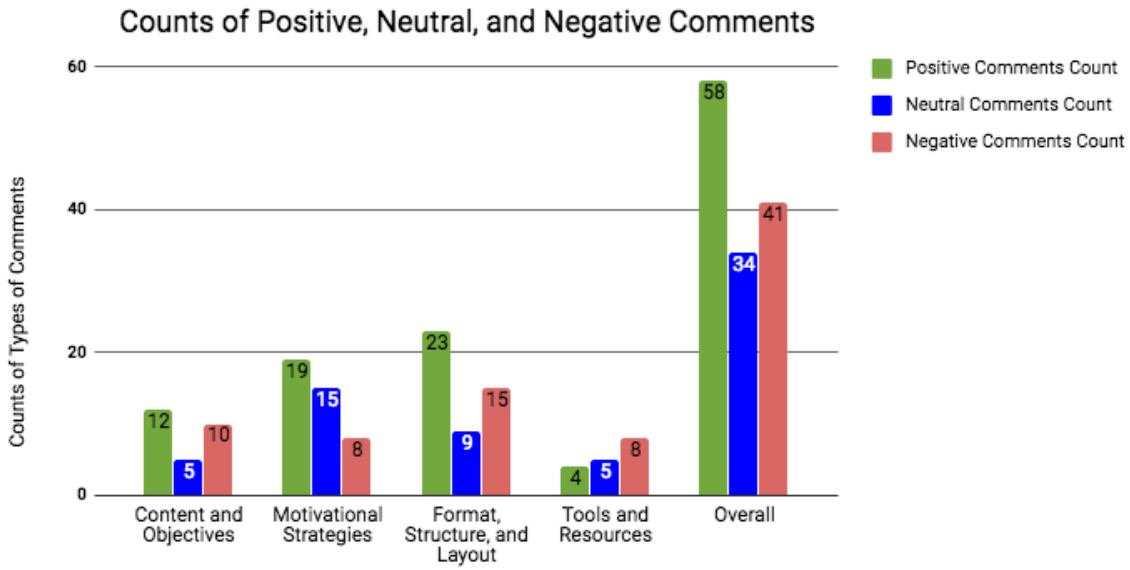

Figure 1. Post-course interview counts of positive, neutral, and negative statements.

In an attempt to quantify the relative positivity of the students' statements, I calculated the mean value of positivity for each category and overall. Figure 2 below displays the mean scores. The purpose of displaying the data in this way was to acknowledge the unequal number of comments in each category, but also to value each category equally. Here it can clearly be seen that all but the Tools and Resources category had a positive effect on the students. The figure also shows the strong negative feelings (-0.235) the students had about the discussion boards and additional resources in the MOOCs. Moreover, the strong positive feelings (0.262) about the MOOCs' ability to motivate the students to stay on track are evident. Overall, the students revealed net positive statements with a score of 0.128.

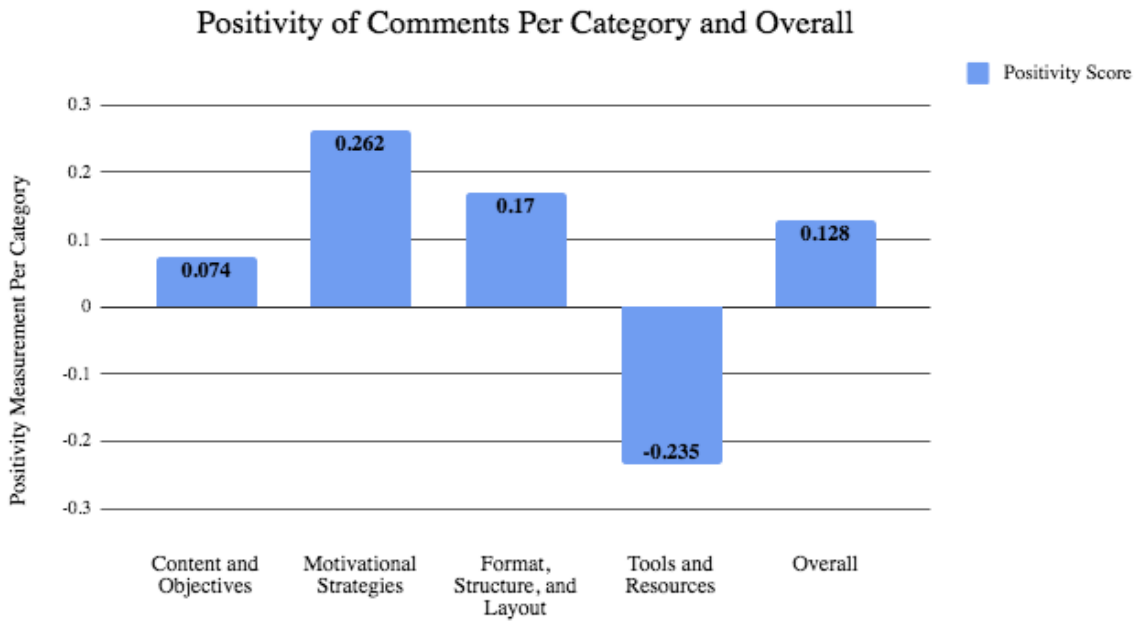

Figure 2. Post-course interview statements' measurements of positivity, (*N*=77).

Considering my research questions, some reasonable conclusions can be drawn from the evidence above. The interviews provided some insight into the best answer to the overarching question. The students frequently noted that the MOOC was an overall positive experience for them and they were happy to have tried this new approach. Although they would have preferred more immediate access to a teacher and some more peer-to-peer interaction, it was clear that the multimedia activities and assessments were appropriately chunked to keep the students motivated and progressing through the content. The immediate feedback from the software allowed them to learn each successive objective while having a larger goal within reach. If the students had the option to go back and repeat this option or choose a more traditional independent study, the data suggests that they would repeat the MOOC.

Surveys

In the interim of the MOOC, the students took surveys to measure their current thoughts and feelings about their productivity and learning. Each student also took a post-course survey. The surveys were conducted on paper and consisted of seventeen Likert-scale statements to which students rated their levels of agreement or disagreement. The surveys were equally spaced in time throughout the MOOC. The students completed the surveys and submitted them to me without a name whereupon I added their individual ID number. The ID number could have been used to compare results to the corresponding interviews and concept inventories.

The questions were chosen for the purpose of quantifying the level of engagement and motivation at points near the middle and end of the MOOC. Some questions measured the ease and helpfulness of the structure and system of the course delivery. Other questions were probes into the students' cognitive ease, or, at least, a sense of competency with the content. Finally, some questions were familiar to any academic course evaluation, especially those found in college courses. The students were able to answer these questions quickly and easily without laboring over the subtle meanings of any word. The surveys gave me additional insight into how the students were using the MOOC and engaging with the content.

Figure 3 below shows a summary of the mid-course survey responses. The important things to note in the table are highlighted. No students strongly disagreed with any item, as highlighted in yellow below. Item 3 (highlighted in red below) received the lowest average score indicating that the students least agreed with the statement: "The activities and assignments help motivate me to stay on track." Item 11 (highlighted in

green below) received the highest average score indicating that the students most agreed with the statement: “There are many opportunities for self-assessment and practice throughout each module.” Each item received a response from all five students.

Statement	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)	Average Score (1-5)
1. This MOOC currently matches my expectations for the course at the start.	0%	0%	0%	80%	20%	4.2
2. The format of the content keeps me engaged with the material.	0%	0%	80%	0%	20%	3.4
3. The activities and assignments help motivate me to stay on track.	0%	20%	80%	0%	0%	2.8
4. The progress tracking feature motivates me to stay on track.	0%	0%	0%	80%	20%	4.2
5. The graded activities are of appropriate level and difficulty.	0%	20%	0%	80%	0%	3.6
6. I like the way the content is organized in discrete modules.	0%	0%	0%	80%	20%	4.2
7. The pace of the content is appropriate.	0%	20%	0%	80%	0%	3.6
8. I feel I am learning the content.	0%	0%	0%	100%	0%	4.0
9. I can find useful help if I get stuck on a problem or activity.	0%	20%	60%	20%	0%	3.0
10. Graded assignments align with the content presentation and practice activities.	0%	20%	20%	60%	0%	3.4
11. There are many opportunities for self-assessment and practice throughout each module.	0%	0%	0%	40%	60%	4.6
12. The readings are helpful for me in learning the content.	0%	0%	20%	80%	0%	3.8
13. The videos are helpful for me in learning the content.	0%	20%	20%	60%	0%	3.4
14. The assessments are helpful for me in learning the content.	0%	0%	20%	60%	20%	4.0
15. I would recommend this MOOC to my peers.	0%	0%	20%	60%	20%	4.0
16. This MOOC has inspired me to learn more about this subject.	0%	20%	40%	40%	0%	3.2
17. I would like to participate in more MOOCs in the future.	0%	0%	60%	40%	0%	3.4

Figure 3. Mid-course survey summary, (*N*=5).

Figure 4 below shows a summary of the post-course survey responses. The important things to note in the table are highlighted. No students strongly disagreed with any item, as highlighted in yellow below. Item 9 (highlighted in red below) received the lowest average score indicating that the students least agreed with the statement: “I was able to find useful help when I got stuck on a problem or activity.” Item 11 (highlighted in green below) received the highest average score indicating that the students most agreed with the statement: “There are many opportunities for self-assessment and practice throughout each module.” Each item received a response from all five students.

Statement	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)	Average Score (1-5)
1. This MOOC matched my expectations for the course at the start.	0%	0%	0%	80%	20%	4.2
2. The format of the content kept me engaged with the material.	0%	0%	40%	40%	20%	3.8
3. The activities and assignments helped motivate me to stay on track.	0%	0%	80%	20%	0%	3.2
4. The progress tracking feature motivated me to stay on track.	0%	0%	0%	80%	20%	4.2
5. The graded activities were of appropriate level and difficulty.	0%	0%	20%	80%	0%	3.8
6. I like the way the content was organized in discrete modules.	0%	0%	0%	60%	40%	4.4
7. The pace of the content was appropriate.	0%	0%	20%	80%	0%	3.8
8. I felt I was learning the content.	0%	0%	0%	100%	0%	4.0
9. I was able to find useful help when I got stuck on a problem or activity.	0%	40%	40%	20%	0%	2.8
10. Graded assignments aligned with the content presentation and practice activities.	0%	0%	40%	60%	0%	3.6
11. There were many opportunities for self-assessment and practice throughout each module.	0%	0%	0%	40%	60%	4.6
12. The readings were helpful for me in learning the content.	0%	0%	20%	80%	0%	3.8
13. The videos were helpful for me in learning the content.	0%	20%	20%	60%	0%	3.4
14. The assessments were helpful for me in learning the content.	0%	0%	0%	60%	40%	4.4
15. I would recommend this MOOC to my peers.	0%	0%	20%	60%	20%	4.0
16. This MOOC has inspired me to learn more about this subject.	0%	0%	40%	60%	0%	3.6
17. I would like to participate in more MOOCs in the future.	0%	0%	60%	40%	0%	3.4

Figure 4. Post-course survey summary, (*N*=5).

The mid-course survey shows that students felt mostly agreeable about using the MOOC as a tool in independent studies. Figure 5 below shows that only 8% of responses were disagreeing with statements about the value and utility of the MOOCs. On the other hand, 67% of the responses agreed with such statements. This strong trend can easily be

seen in the following figure. At this point in the course, the students were feeling competent and confident about their progress.

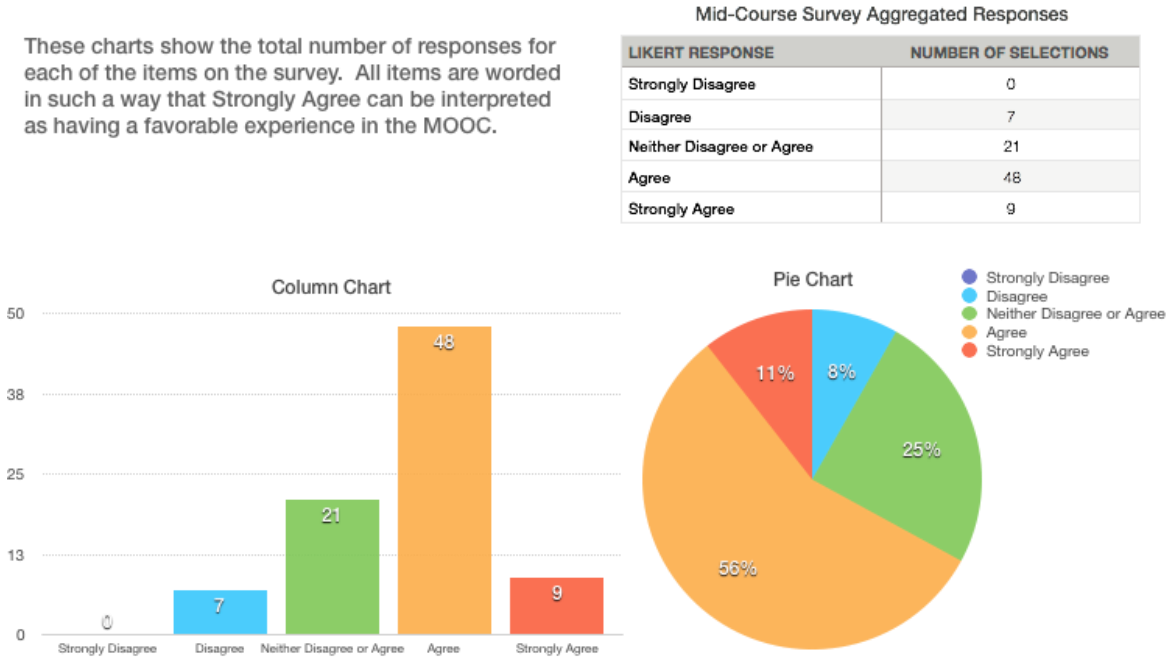

Figure 5. Mid-course survey overview, (*N*=85).

The post-course survey provides even stronger evidence that students felt mostly agreeable about using the MOOC as a tool in independent studies. Figure 6 below shows that only 4% of responses were disagreeing with statements about the overall value and utility of the MOOCs. On the other hand, 73% of the responses agreed with such statements. Considering all items were written in such a way that agreement represents a better experience with the course, it was clear that the students were quite satisfied. Despite only five survey respondents, this figure is evidence to support using a MOOC in high school independent studies.

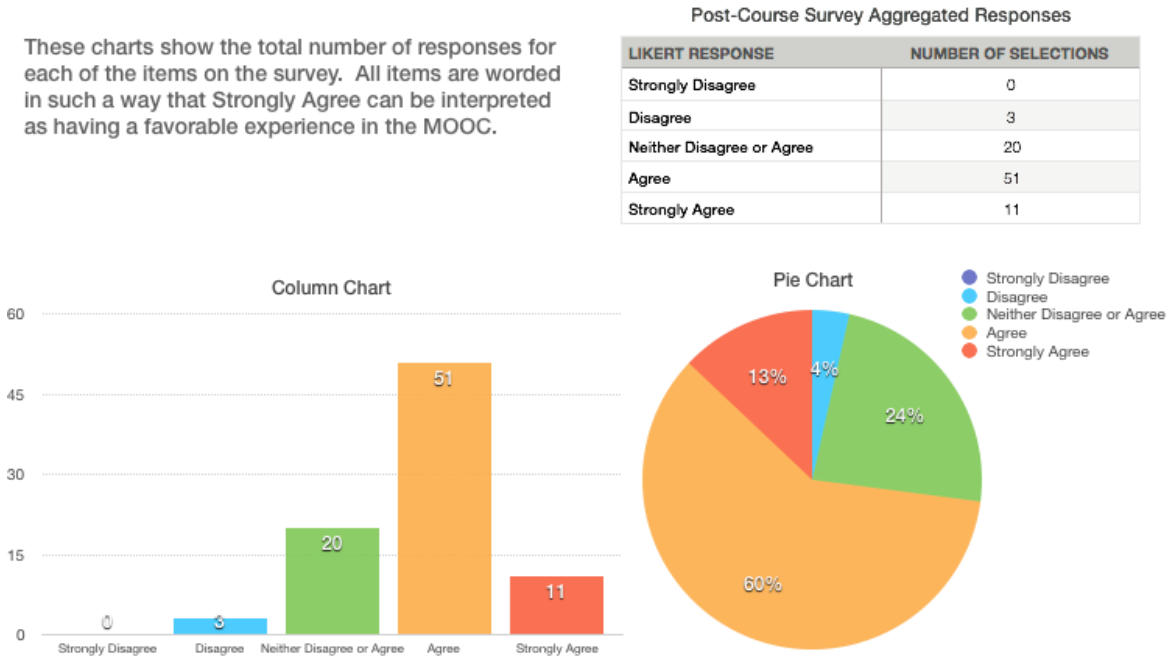

Figure 6. Post-course survey overview, (*N* =85).

Figure 7 below shows the agreeability of statements on the mid-course survey related to the Content and Objectives coding category. The students agreed with 69% of these statements, while only 11% disagreed. It was apparent that the students were satisfied with how the material aligned with their goals. This is more evidence that a MOOC can be used to provide guidance and structure to the independent-study experience.

These charts show the responses for items 1, 3, 5, 7, 10, 12, 13, 14, and 15 on the mid-course survey.

These items correspond to responses related to coding category: Content and objectives.

Post-Course Survey Aggregated Responses

LIKERT RESPONSE	NUMBER OF SELECTIONS
Strongly Disagree	0
Disagree	5
Neither Disagree or Agree	9
Agree	28
Strongly Agree	3

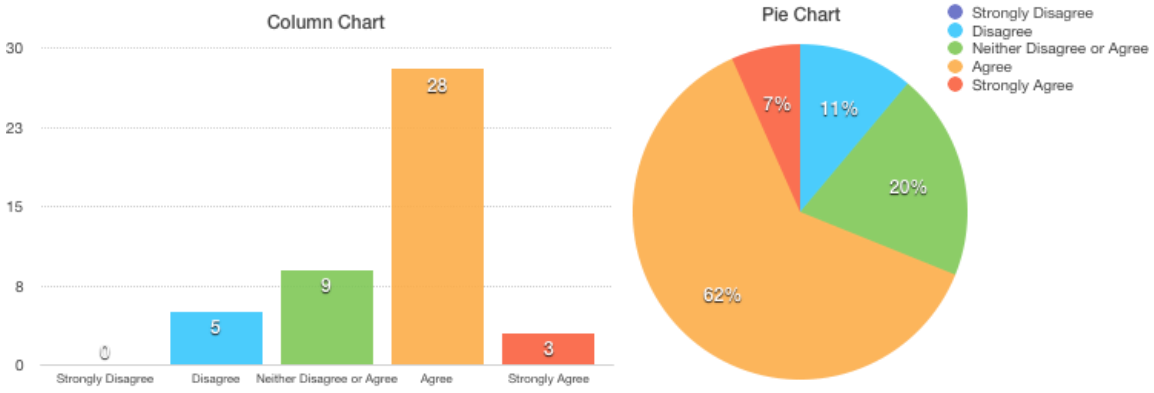

Figure 7. Mid-course survey Content and Objectives category overview, (*N*=45).

Figure 8 below shows the agreeability of statements on the mid-course survey related to the Motivational Strategies coding category. The students agreed with 67% of these statements, while only 7% disagreed. It was apparent that the students were satisfied with how the progress tools were motivating them to stay on track. This is more evidence that a MOOC can have a positive impact on students' attitudes and motivations in an independent-study experience.

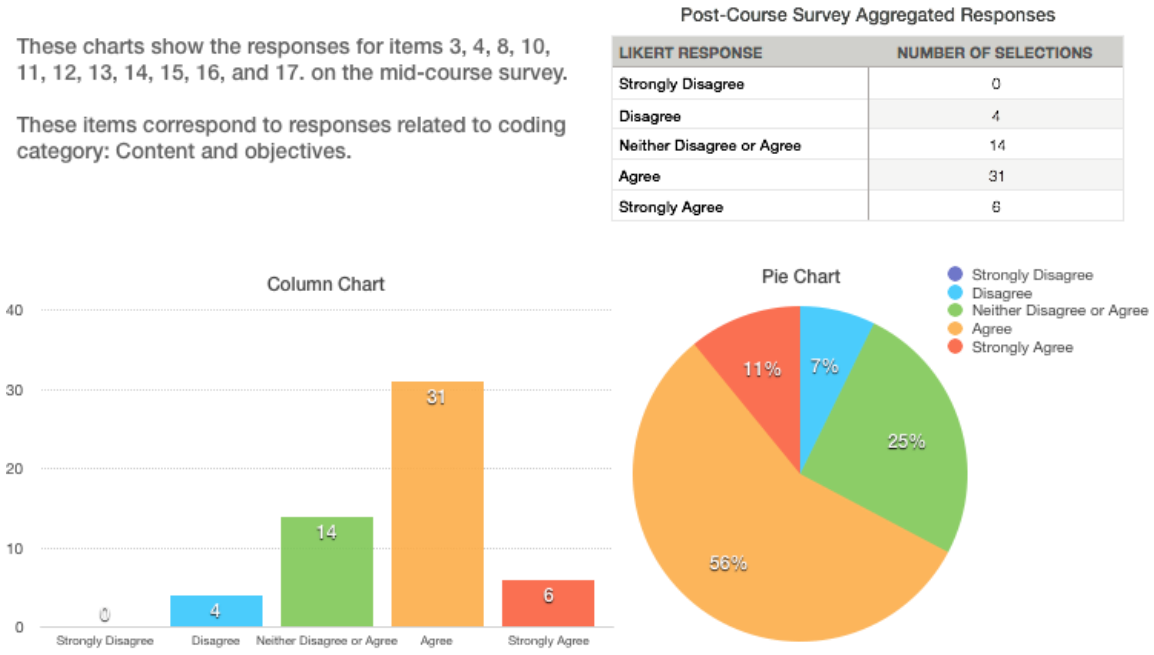

Figure 8. Mid-course survey Motivational Strategies category overview, (*N*=55).

Figure 9 below shows the agreeability of statements on the mid-course survey related to the Format and Structure coding category. The students agreed with 71% of these statements, while only 6% disagreed. It was very clear that the students were satisfied with the design of the modules. This is more evidence that a MOOC can be used to provide guidance and structure to the independent-study experience.

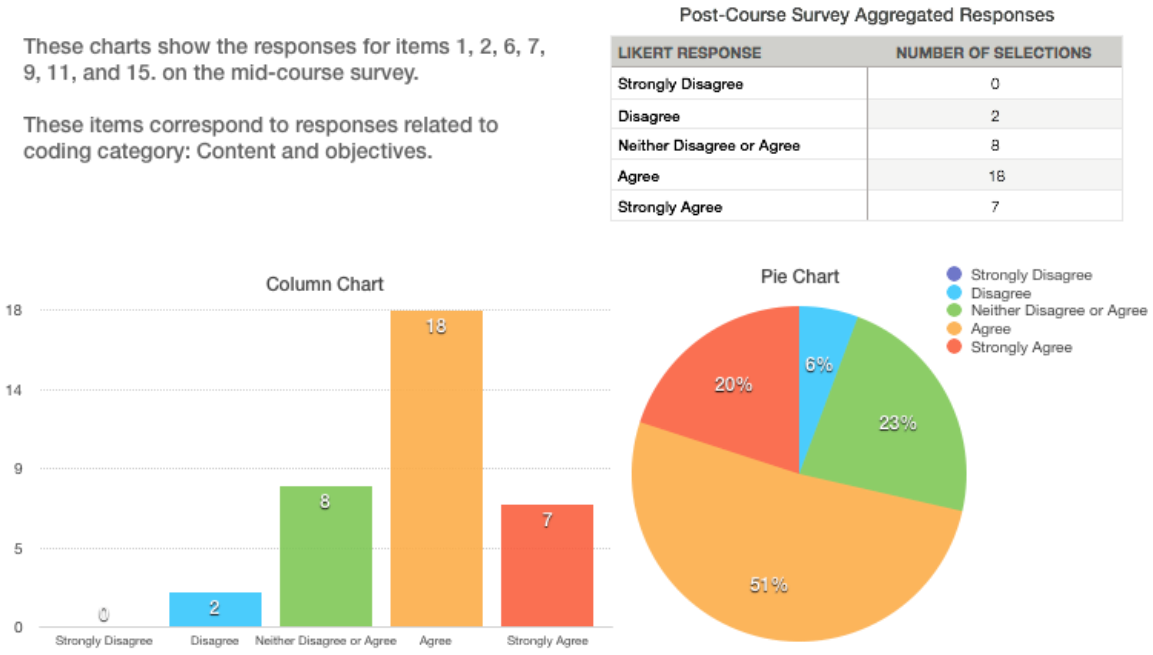

Figure 9. Mid-course survey Format and Structure category overview, (*N*=35).

Figure 10 below shows the agreeability of statements on the mid-course survey related to the Tools and Resources coding category. The students agreed with 68% of these statements, while only 8% disagreed. This is more evidence that a MOOC can provide some positive tools and resources in MOOCs that add to the independent-study course. However, it should be restated here that the survey did not have questions specifically asking about the discussion board in the MOOC. This fact largely explains the discrepancy between the agreement here and the negative score from the post-course interview in which the students expressed considerable dissatisfaction with the discussion boards.

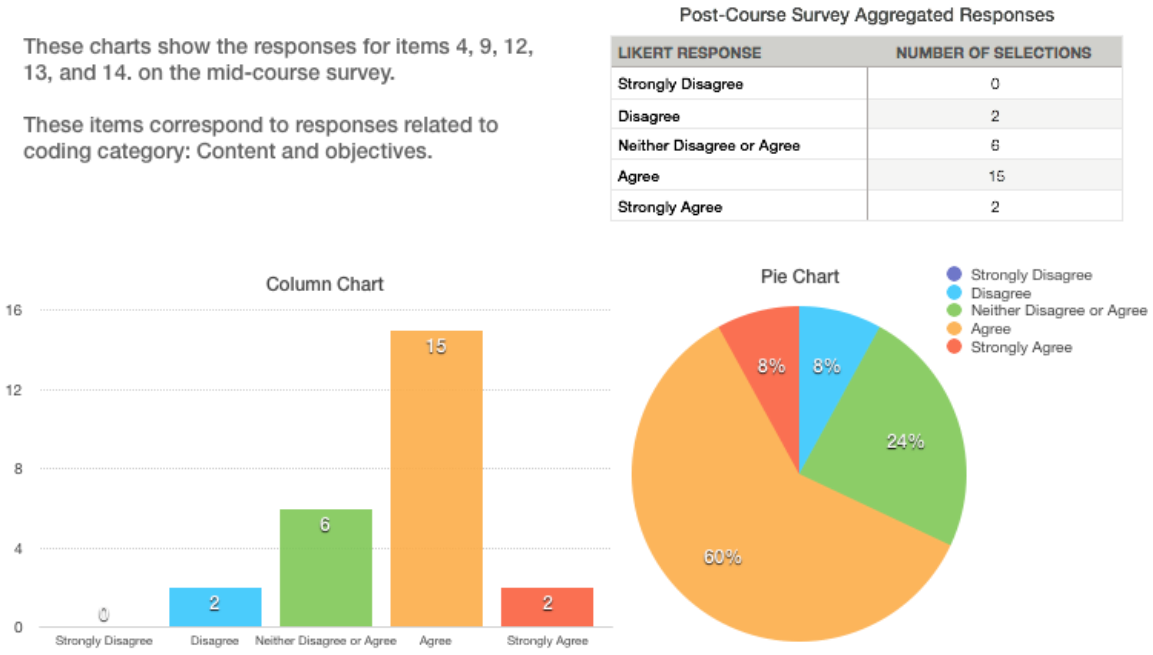

Figure 10. Mid-course survey Tools and Resources category overview, (*N*=25).

Figure 11 below shows the agreeability of statements on the post-course survey related to the Content and Objectives coding category. As in the mid-course survey, it was again apparent that the students were satisfied with how the material aligned with their goals. The students agreed with 73% of these statements, while only 2% disagreed. This is strong evidence that a MOOC can be used to provide guidance and structure to the independent-study experience.

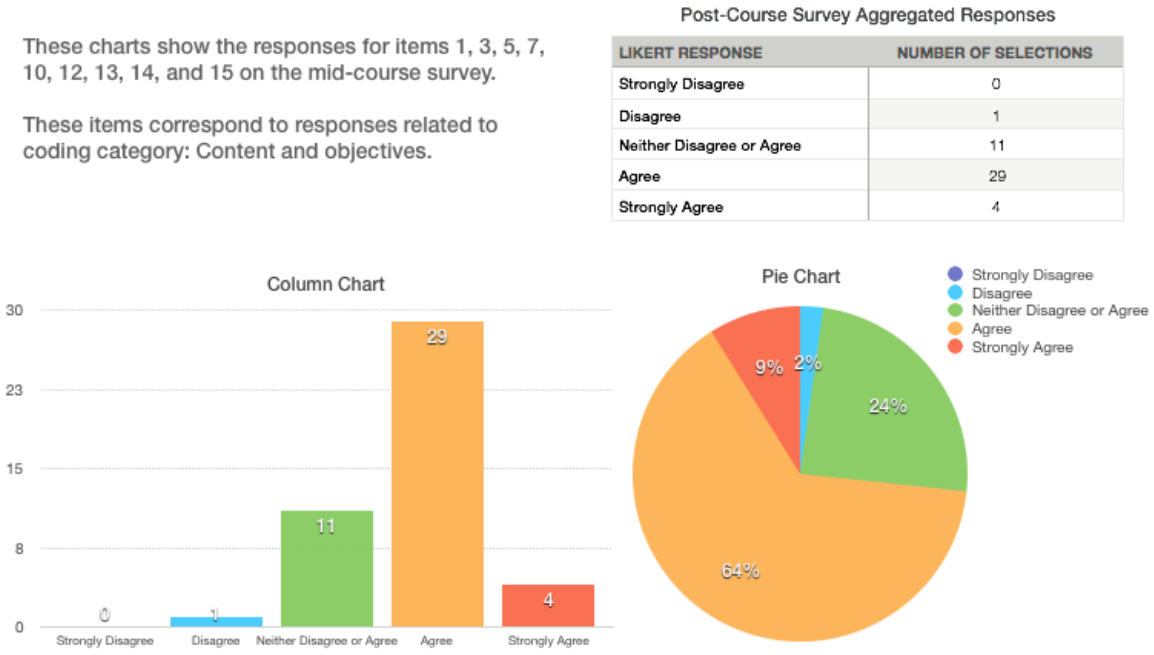

Figure 11. Post-course survey Content and Objectives category overview, (*N*=45).

Figure 12 below shows the agreeability of statements on the post-course survey related to the Motivational Strategies coding category. As in the mid-course survey, it was again apparent that the students were satisfied with how the progress tools were motivating them to stay on track. The students agreed with 73% of these statements, while only 2% disagreed. This is the strongest evidence that a MOOC can have a positive impact on students' attitudes and motivations in an independent-study experience.

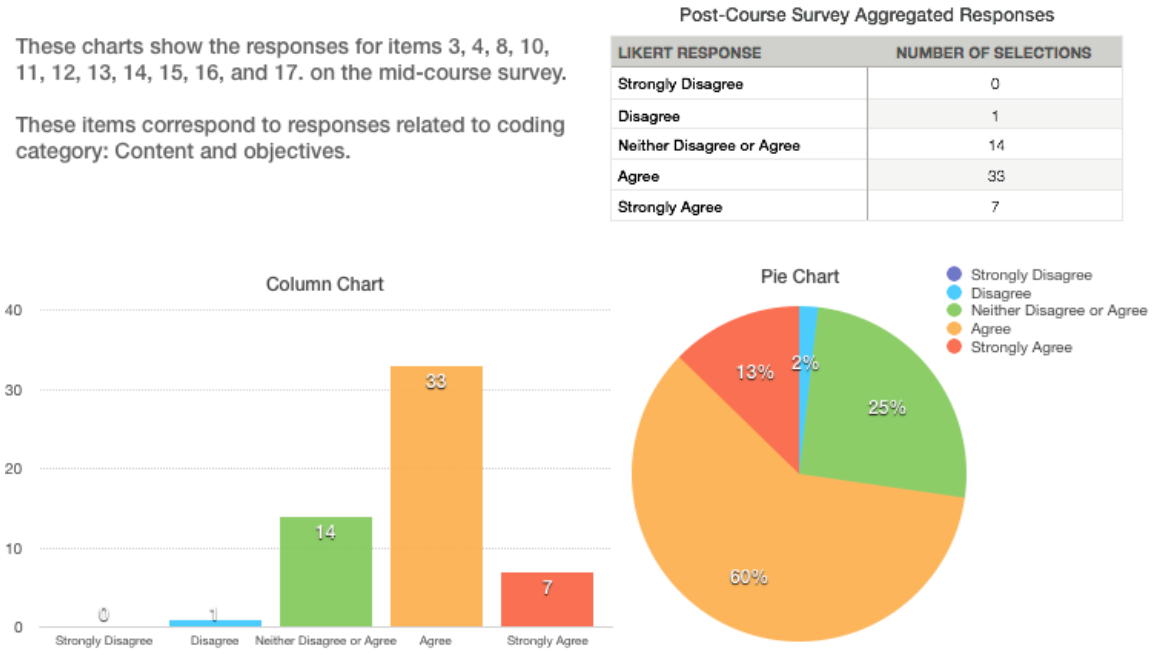

Figure 12. Post-course survey Motivational Strategies category overview, (*N*=55).

Figure 13 below shows the agreeability of statements on the post-course survey related to the Format and Structure coding category. As in the mid-course survey, it was again apparent that the students were satisfied with the design of the modules. The students agreed with 77% of these statements, while only 6% disagreed. This is strong evidence that a MOOC can be used to provide guidance and structure to the independent-study experience.

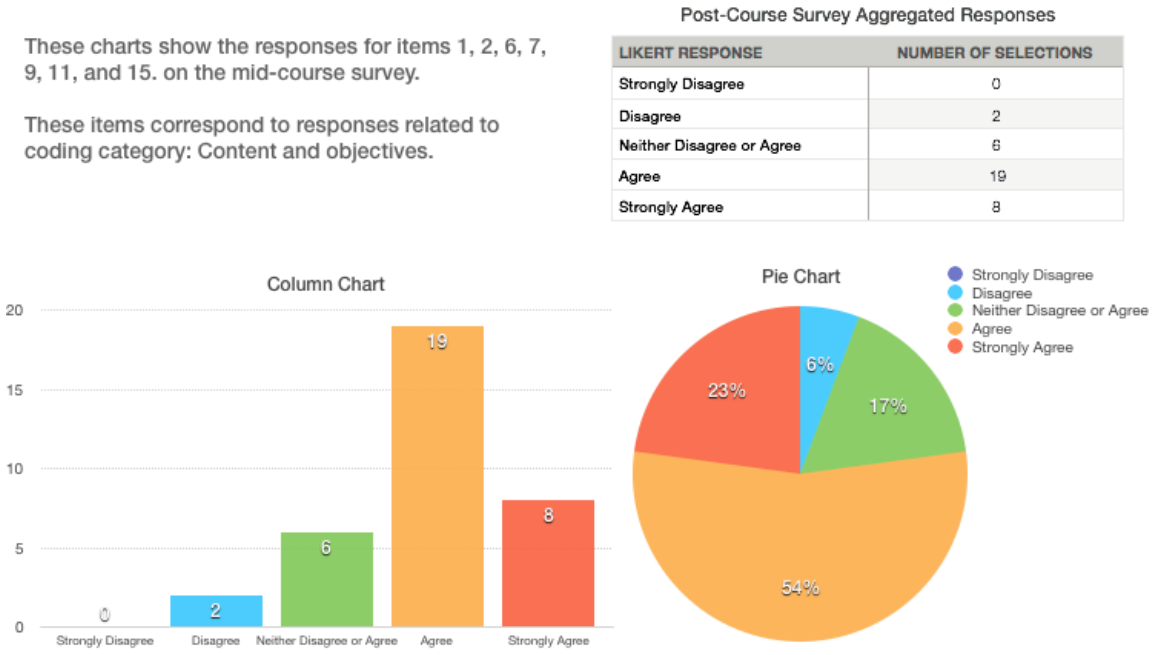

Figure 13. Post-course survey Format and Structure category overview, (*N*=35).

Figure 14 below shows the agreeability of statements on the post-course survey related to the Tools and Resources coding category. The students agreed with 72% of these statements, while only 12% disagreed. This is also strong evidence that a MOOC can provide some positive tools and resources in MOOCs and to the independent-study course. However, as with the mid-course survey, it should be restated here that the survey did not have questions specifically asking about the discussion board in the MOOC. This fact largely explains the discrepancy between the agreement here and the negative score from the post-course interview.

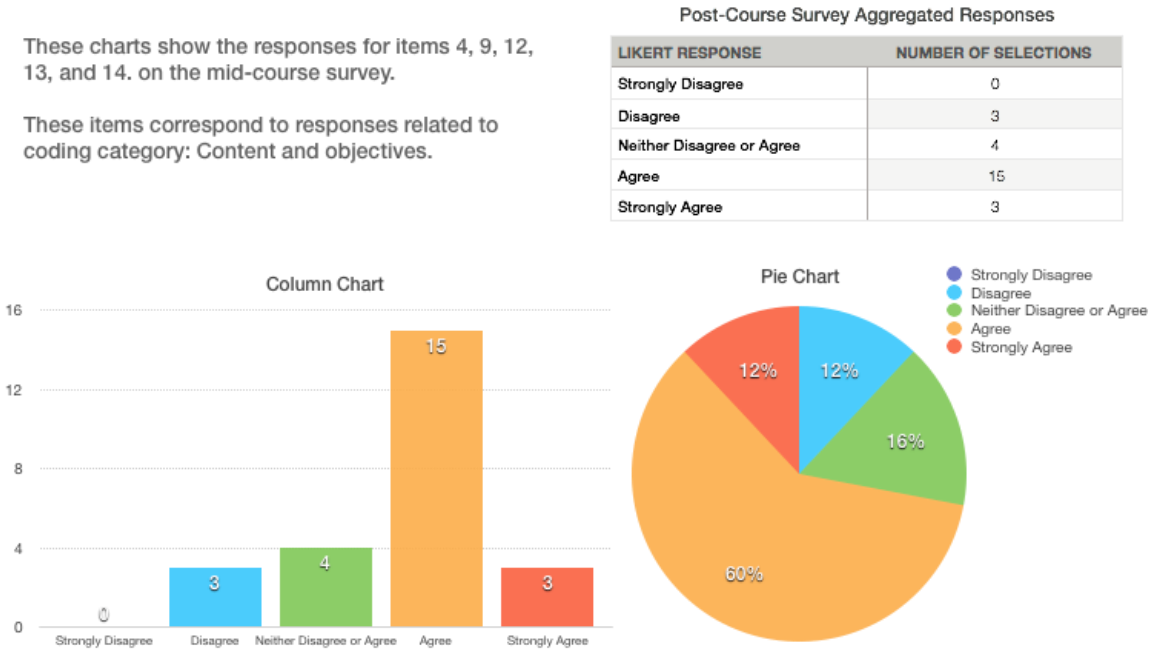

Figure 14. Post-course survey Tools and Resources category overview, (*N*=25).

Discussion on Survey Design Limitations

If I were to use the surveys again, there are a few things I would change. The first is the order of the questions. I would reorder the questions according to the coding system I chose to use in analyzing the interviews. The codes were chosen after implementing the mid-course survey. I recognize that this was not the best experimental design. Secondly, I would add an item that specifically addressed the discussion boards. Prior to the post-course interview, I was not aware of the strong negative feelings students had about the online discussion forums. It would have been nice to have survey evidence to corroborate such feelings. Lastly, I would have broken a few questions into parts that may have probed deeper into students' perceptions. For example, item number five reads "The graded activities are of appropriate level and difficulty." I would change

this into two items reading: “The graded activities are too easy.” and “The graded activities are too difficult.” I think this would correct the original item’s ambiguity.

Concept Inventories

Four of the five students took the Brief Electricity & Magnetism Assessment (BEMA) concept inventory to measure their gains in conceptual knowledge about the emphasized topics in their respective courses. The fifth student did not take the BEMA, because the MOOC involved was a mathematics course in differential equations and is thus not aligned to the assessment targets of the BEMA. The BEMA allowed me to make comparisons of objective conceptual gains with students’ perceptions of gains.

The BEMA was given as a pretest and posttest on paper. Each assessment was marked with the appropriate ID number upon submission to me. For the MOOC to be considered academically successful, I expected to see some gains in scores on the posttest. The following figures show that gains did occur.

Figure 15 below shows the comparison between the pre-test and post-test raw scores on the BEMA. The maximum possible score was 31. The average pre-test score was 9.75, while the average post-test score was 19.5. Each student experienced a gain in performance. The average gain was 9.75 points.

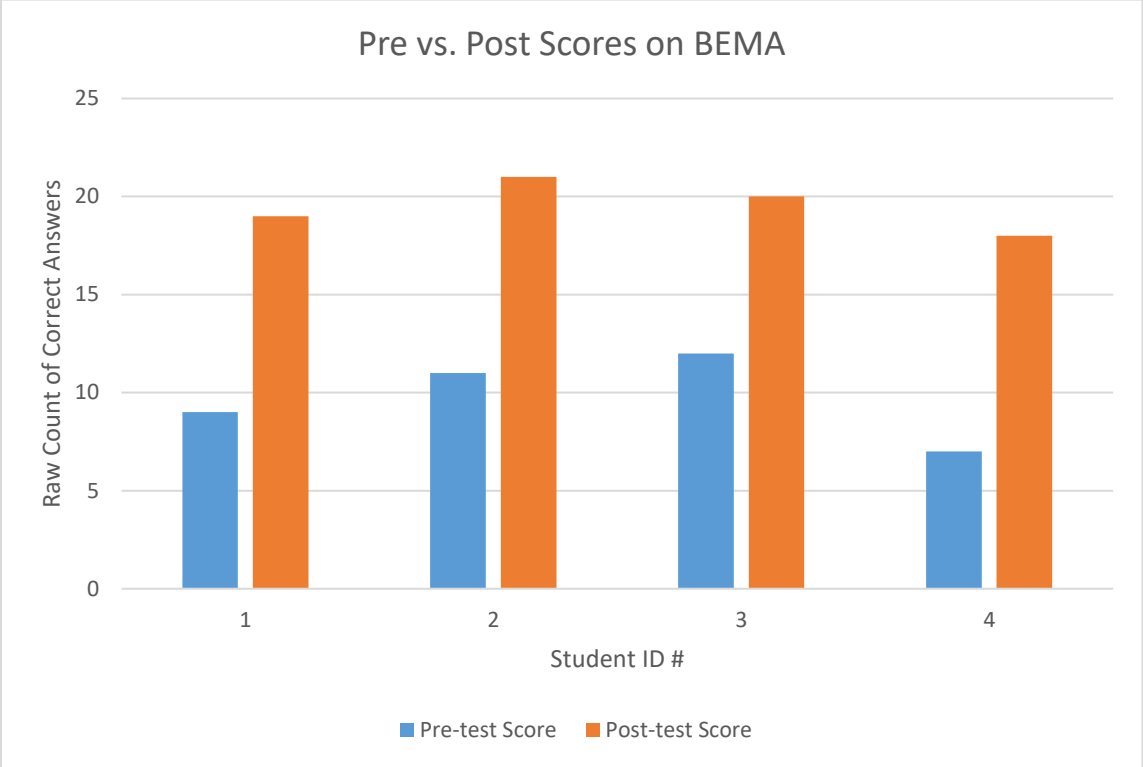

Figure 15. Raw scores comparison on BEMA pre-test and post-test, (*N*=4).

Figure 16 below shows the comparison between the pre/post-test gains and possible gains on the BEMA. The average gain was 9.75 points. The average possible gain was 21.25. The ratio of gain : possible gain is represented by the slope of the trend line. The average gain to possible gain ratio (normalized gain or *g*) was 0.46. This ratio reveals a strong growth in conceptual learning at the end of the course. Substantial research has been done on large populations of college students in physics courses of similar content where average normalized gains range from 0.30 to 0.43 (Kohlmyer, 2009). It should be noted that the students in this case study are not a random selection. The four students who took the BEMA are highly-motivated students among the highest achievers in their class. Nonetheless, the gains they exhibited should not be ignored.

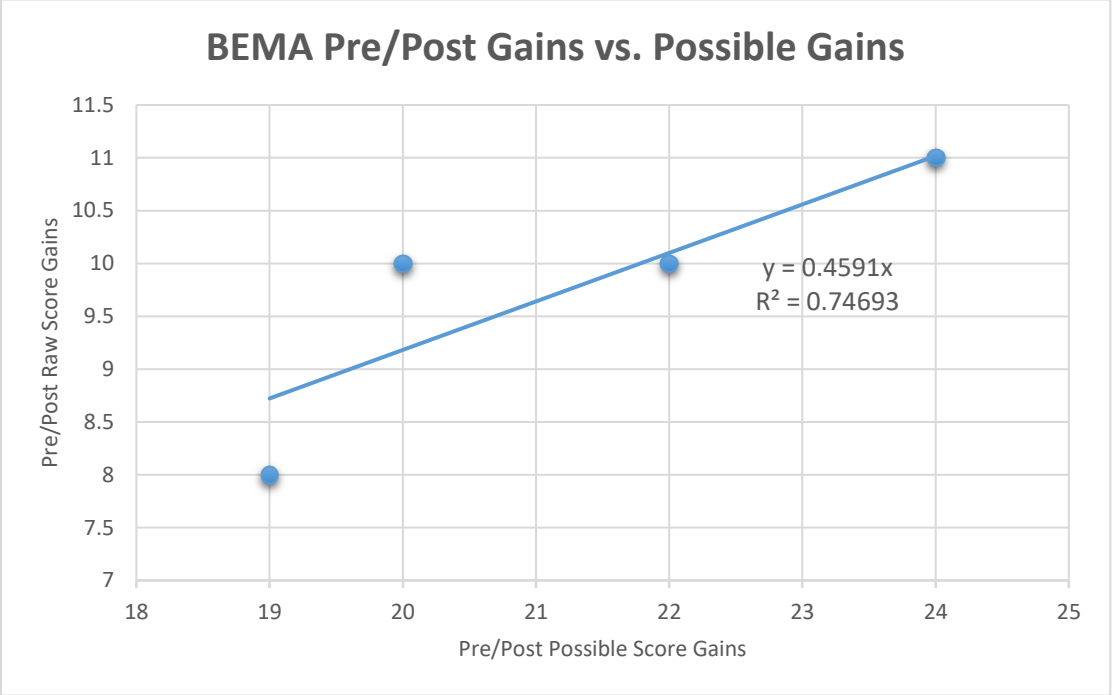

Figure 16. Gains vs. possible gains on BEMA pre-test and post-test, (*N*=4).

Summary of Data Analysis

Ultimately, I was able to triangulate some information from the collection of methods to establish a level of impact on the students so that I can make informed decisions about using a MOOC in future independent study courses. Some results were slightly surprising; some were contradictory. Nonetheless, the level of motivation and progress expressed by the students in the interviews was reflected in the data from the surveys and concept inventories. The limited sample size does make it difficult for me to draw large conclusions that can be generalized beyond my school. This case study approach is only a first investigation into some larger research that could be done.

With respect to my original research questions, I believe the data provide some tentative answers. When considering my primary question, "What impact can MOOCs

have in high school independent-study enrichment courses?", I think the interview, survey, and concept inventory data suggest that MOOCs can have a primarily positive impact as long as they are actively managed by a knowledgeable teacher who is easily accessible in the school setting. Traditional independent studies are entirely directed by the student. MOOCs can provide a high-quality delivery mechanism of content from experts, which allows for more opportunities in schools where there are underqualified teachers. However, it seems that teachers need to be actively involved in the progress of each student. This active management should provide a means of overcoming the negative responses students had about the online discussion forums.

It was clear from each of the data sets that the MOOC provided a positive course structure that gave students substantial guidance in the learning process. Moreover, the students displayed general attitudes that helped their motivations in completing the courses. Lastly, the tools embedded in the MOOCs were valuable in that they allowed students to track their progress, thus, promoting continual growth.

INTERPRETATION AND CONCLUSION

Revisiting the research questions, I think I have evidence to support a decision to continue using MOOCs, at least as part of an independent study. The results of my research support Rolin Moe's conclusion that some MOOCs offer extraordinary experiences that lead to substantial learning and, therefore, schools should be investing time and resources into MOOCs (Moe, 2014). The students agreed that the MOOC has provided rigorous content and appropriate objectives. Scores on the BEMA corroborate this perception. The Pennsylvania Department of Education accurately described my

students' preconceptions in stating that independent studies "may be more challenging than a traditional course because a student is operating without peer support and is responsible for staying on track without teacher reminders or outlines" (Education, 2016 p. 2). Nevertheless, the students agreed that the MOOC motivated them to stay on track while progressing through content. Furthermore, my students' access to a teacher and an in-school support structure was better represented as what Najafi, Evans, and Federico described—a blended mode. Prior research falls in line with my findings in that MOOC-only students appeared to be better at online assessments, while the blended-mode students were more likely to stay on-track and complete the MOOC (Najafi, 2014). Interviews and surveys show that the students were generally satisfied with the tools and resources provided by the MOOC despite their dislike of the discussion boards. The opportunity to try something new and to maintain ownership of their own learning was a common theme that arose during the pre- and post-interviews. This finding is not surprising given that students who are more invested in the choice of methods for learning and assessment are more likely to sustain their learning in the future (Glasser, 1998).

Examining this particular experience in fine detail has given me an informed perspective for future cases. In considering the research question, "What impact can MOOCs have in high school independent-study enrichment courses?", I believe there is ample evidence in this case study to suggest that MOOCs can have a positive impact and, therefore, can be used to guide and support students seeking such enrichment opportunities.

VALUE

A large part of leadership in any organization, particularly in education, is getting a seat at the table where influential conversations take place. A case study like the one described above offers me a chance to have a voice in those conversations. Conducting the research in a meaningful and deliberate manner has provided me a list of talking points. Moreover, the detailed analysis legitimizes my voice at the table.

Decisions are often made in meetings that are overfilled with agenda items. Leaders often trust anecdotal evidence and gut feelings when placing their final votes on policies. As organizations, such as the Commonwealth of Pennsylvania, begin formalizing structures of independent studies at various levels, it is imperative that policies be based on robust evidence. This is not to say that my case study reaches hard conclusions that can be scaled to statewide policy, however, it does set a standard for the level of evidence-based reasoning that is needed in the decision-making process. I believe that the biggest value of my work here is symbolic. It is a commitment to systematic investigation in order to reveal more than an anecdote or gut feeling.

Prior to beginning this case study, I had mentored several students engaged in independent studies. Over the years, I began to notice that these courses were not effective. That is, they were not providing the breadth and depth of learning that I knew these students were capable of. The students and I agreed that there was a discrepancy between expectation and achievement. I accept responsibility for part of this discrepancy that was due to my mismanagement of the coursework. I was not happy with the quality of feedback I was providing students. They needed more guidance and structure from me

than my schedule could provide. Nonetheless, I was committed to helping those students who were taking on new challenges in ways that teachers often dream of. It was time for me to try something new.

A MOOC seemed to be a convenient way to provide structure, guidance, and feedback to students. The online platform was free and it was ready-made with internal quality control by having courses taught by established professors at reputable higher education institutions. At first glance, it would seem to make sense to use a MOOC, but a truly skeptical mind pauses at a hunch in favor of more evidence. This case study was an important step in taking responsibility for my students' learning. If I have opportunities in the future to mentor students in their independent studies, I certainly will consider advising them to use a MOOC.

With that said, there are some lingering questions that need answering before I would recommend using a MOOC in all schools with independent studies. First of which is: *Is the planning and managing aspect of an independent study more important than the content to be learned?* In other words: *Are students better off having failed at a task that they personally designed or better off having learned content from a MOOC?* A second question worth answering is: *What role should the high school teacher play while the students are participating in the MOOC?* Lastly: *Should the high school require a summative assessment beyond those offered in the MOOC?* The goals of students who are seeking enrichment in subjects that extend beyond the curriculum can vary widely. In some ways, a MOOC could be restrictive to a student's creativity, but in other ways, a MOOC can open windows of knowledge inaccessible with just a library and the internet.

Most (if not all) students need our guidance and wisdom in making the best decisions in learning new things. It is our responsibility to give them the best evidence-based advice we can. Further research to answer the above questions will help us do just that.

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APPENDICES

APPENDIX A

PRE-COURSE INTERVIEW QUESTIONS

PRE-COURSE INTERVIEW QUESTIONS

- Have you taken a MOOC before?
- Do you think MOOCs can be an effective means of guiding and assessing an independent study?
- What are some advantages of using a MOOC in an independent study?
- What are some disadvantages of using a MOOC in an independent study?
- What features do you think will be needed to keep you engaged through completion of the course?
- What originally motivated you to do an independent study?
- How strongly are you motivated now? Why?
- Do you think a MOOC could work for all students interested in an independent study?
- Does it matter to you that the MOOC you are taking is from a reputable university?
- How will you know if the MOOC has been a valuable experience?

APPENDIX B

POST-COURSE INTERVIEW QUESTIONS

POST-COURSE INTERVIEW QUESTIONS

- What are your general impressions about the specific MOOC you recently finished?
- How would you describe the difficulty of the content in this course?
- How would you describe the difficulty navigating the MOOC interface?
- Overall did you feel you were motivated and engaged by the course? What contributed to this?
- Do you feel that you had the tools you needed to succeed?
- Do you think MOOCs can be an effective means of guiding and assessing an independent study?
- What are some advantages of using a MOOC in an independent study?
- What are some disadvantages of using a MOOC in an independent study?
- If you were to do this again, what features do you think would need to be added to keep you engaged through completion of the course?
- What originally motivated you to do an independent study?
- Has this MOOC changed your perceptions of the concepts? How so? Why?
- Do you think a MOOC could work for all students interested in an independent study?
- Did it matter to you that the MOOC you finished was from a reputable university?
- Overall, was the MOOC a valuable experience? Why?

APPENDIX C

MID-COURSE SURVEY

MID-COURSE SURVEY

Please answer the following questions by circling or underlining the option that best represents your opinion at this moment. If you have any concerns about the meaning of any question, please do not hesitate to ask Mr. Spicer for clarification. Also, recall that participation is voluntary and you can choose to not answer any questions you do not want to answer and/or you can stop at any time. Your participation or non-participation will not affect your grade or class standing.

1. This MOOC currently matches my expectations for the course at the start.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

2. The format of the content keeps me engaged with the material.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

3. The activities and assignments help motivate me to stay on track.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

4. The progress tracking feature motivates me to stay on track.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

5. The graded activities are of appropriate level and difficulty.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

6. I like the way the content is organized in discrete modules.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

7. The pace of the content is appropriate.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

8. I feel I am learning the content.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

9. I can find useful help if I get stuck on a problem or activity.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

10. Graded assignments align with the content presentation and practice activities.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

11. There are many opportunities for self-assessment and practice throughout each module.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

12. The readings are helpful for me in learning the content.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

13. The videos are helpful for me in learning the content.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

14. The assessments are helpful for me in learning the content.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

15. I would recommend this MOOC to my peers.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

16. This MOOC has inspired me to learn more about this subject.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

17. I would like to participate in more MOOCs in the future.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

APPENDIX D

POST-COURSE SURVEY

POST-COURSE SURVEY

Please answer the following questions by circling or underlining the option that best represents your opinion at this moment. If you have any concerns about the meaning of any question, please do not hesitate to ask Mr. Spicer for clarification. Also, recall that participation is voluntary and you can choose to not answer any questions you do not want to answer and/or you can stop at any time. Your participation or non-participation will not affect your grade or class standing.

1. This MOOC matched my expectations for the course at the start.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

2. The format of the content kept me engaged with the material.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

3. The activities and assignments helped motivate me to stay on track.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

4. The progress tracking feature motivated me to stay on track.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

5. The graded activities were of appropriate level and difficulty.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

6. I liked the way the content is organized in discrete modules.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

7. The pace of the content was appropriate.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

8. I felt I was learning the content as I progressed through the modules.

   Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

9. I was able to find useful help when I get stuck on a problem or activity.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

10. Graded assignments aligned with the content presentation and practice activities.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

11. There were many opportunities for self-assessment and practice throughout each module.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

12. The readings were helpful for me in learning the content.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

13. The videos were helpful for me in learning the content.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

14. The assessments were helpful for me in learning the content.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

15. I would recommend this MOOC to my peers.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

16. This MOOC has inspired me to learn more about this subject.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

17. I would like to participate in more MOOCs in the future.

Strongly Disagree Disagree Neither Disagree or Agree Agree Strongly Agree

APPENDIX E

BRIEF ELECTRICITY AND MAGNETISM ASSESSMENT

Brief Electricity and Magnetism Assessment (BEMA)

Version 1

PhysPort
Supporting physics teaching with research-based resources

Developed by: Ruth Chabay and Bruce Sherwood
Format: Pre/post, Multiple-choice
Duration: 45 minutes
Focus: Electricity / Magnetism Content Knowledge (Circuits, Electrostatics, Magnetic Fields and Forces)
Level: Upper-level, Intro College

Security Warning!

Students may not have unsupervised access to this assessment instrument!
It takes many years to create and validate reliable assessment instruments.
If students can access and study from them, these instruments lose their validity.

Please do **not**:

- allow students to keep copies of this instrument
- post this instrument on a website without security to prevent copying, downloading or sharing
- share this instrument with anyone who hasn't agreed to these guidelines

How to give the test

- You can give it as both a pre- and post-test to measure student learning, or give it as a post-test only, since students don't have much initial knowledge of E&M and average pre-test scores are usually similar at different institutions
  - Give the pre-test before you cover relevant course material.
  - Give the post-test at the end of the term.
- Use the whole test, with the original wording and question order, so comparisons with other classes are meaningful.
- Make the test required, and give credit for completing the test (but not correctness). This ensures maximum participation from your students.
- Tell your students that the test is designed to evaluate the course (not them), and that knowing how they think will help you teach better. Tell them that correctness will not affect their grades (only participation). This helps alleviate student anxiety.
- Refer to the test by a generic title like "Electricity / Magnetism Survey" to prevent students from looking up the answers.
- For more details, read the **PhysPort Guides** on implementation:
  - **PhysPort BEMA implementation guide** (www.physport.org/implementation/BEMA)
  - **PhysPort Expert Recommendation on Best Practices for Administering Concept Inventories** (www.physport.org/expert/AdministeringConceptInventories/)

How to score the test

- Download the answer key from PhysPort (www.physport.org/key/BEMA)
- The developers advocate a scoring scheme where some questions have different weighting. For instructions of calculating the score, see the **PhysPort BEMA Implementation Guide** (www.physport.org/implementation/BEMA)
- See the **PhysPort Expert Recommendation on Best Practices for Administering Concept Inventories** for instructions on calculating normalized gain and effect size (www.physport.org/expert/AdministeringConceptInventories/)
- Use the **PhysPort Assessment Data Explorer** for analysis and visualization of your students' responses (www.physport.org/explore/BEMA)

Two small objects each with a net charge of +Q exert a force of magnitude F on each other:

We replace one of the objects with another whose net charge is +4Q:

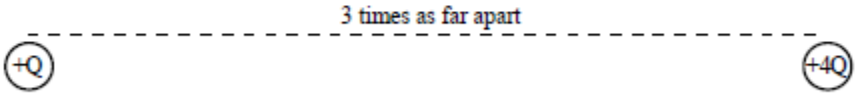
→ **Q1** The original magnitude of the force on the +Q charge was F; what is the magnitude of the force on the +Q charge now?

(a) 4F
(b) 5F/2
(c) 3F
(d) 2F
(e) F
(f) F/4
(g) None of the above

→ **Q2** What is the magnitude of the force on the +4Q charge?

(a) 4F
(b) 5F/2
(c) 3F
(d) 2F
(e) F
(f) F/4
(g) None of the above

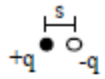
Next we move the +Q and +4Q charges to be 3 times as far apart as they were:



→ **Q3** Now what is the magnitude of the force on the +4Q charge?

(a) 4F/3
(b) 4F/9
(c) F/3
(d) 5F/18
(e) 2F/9
(f) F/9
(g) F/36
(h) 4F
(i) None of the above

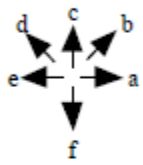
Here are two charges of equal magnitude but opposite sign, separated by a distance s:



1 ×

2 ×

Choose from the following possible directions to answer the questions below:



⊙ out of page g

⊗ into page h

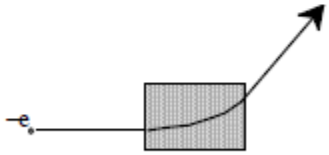
zero magnitude i

None of the above j

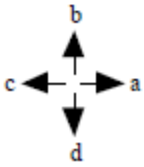
→ **Q4** What is the direction (a-j) of the electric field at location 1 (marked with an ×)?

→ **Q5** What is the direction (a-j) of the electric field at location 2 (marked with an ×)?

A moving electron with charge -e travels along the path shown, and passes through a region of electric field. There are no other charges present. The electric field is zero everywhere except in the gray region.



Choose from the following possible directions to answer the question below:



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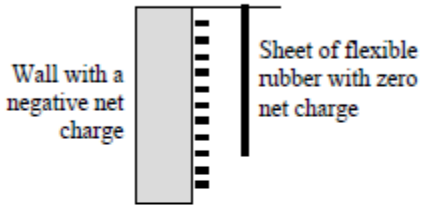
None of the above g

→ **Q6** What is a possible direction (a-g) of the electric field in the region where the field is non-zero?

A non-conducting wall is given a negative net charge. Next, a sheet of very flexible rubber with zero net charge is suspended from the ceiling near the charged wall as shown below.



→ Q7 The rubber sheet will:

(a) not be affected by the charges on the wall since rubber is an insulator.

(b) not be affected by the charged wall because the rubber sheet has zero net charge.

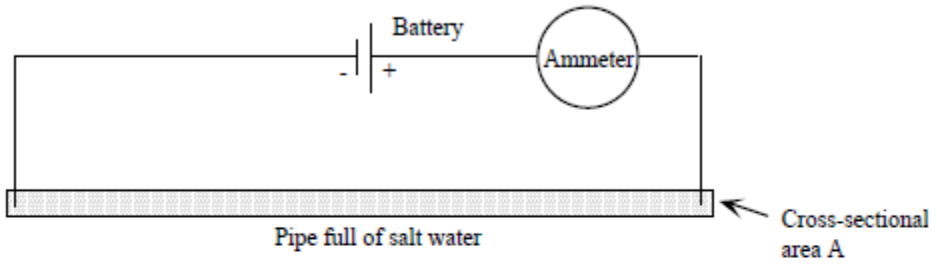
(c) bend away from the wall due to the electrical repulsion between the electrons in the rubber and the charges on the wall.

(d) bend away from the wall due to the polarization of the rubber molecules by the charged wall.

(e) bend toward the wall due to the polarization of the rubber molecules by the charged wall.

(f) none of the above.

Salt water contains n sodium ions (Na^+) per cubic meter and n chloride ions (Cl^-) per cubic meter. A battery is connected to metal rods that dip into a narrow pipe full of salt water. The cross-sectional area of the pipe is A:



→ **Q8** What is the direction of conventional current flow in the salt water?

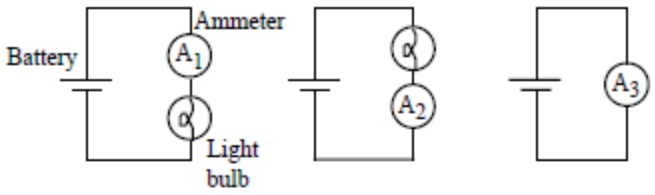
(a) To the right.
(b) To the left.
(c) There is no conventional current, because the motions of the positive and negative ions cancel each other out.

The magnitude of the drift velocity of the sodium ions is v_{Na}, and the magnitude of the drift velocity of the chloride ions is v_{Cl}. Assume that $v_{Na} > v_{Cl}$. (+e is the charge of a proton.)

→ **Q9** What is the magnitude of the ammeter reading?

(a) $enAv_{Na} - enAv_{Cl}$
(b) $enAv_{Na} + enAv_{Cl}$
(c) $enAv_{Na}$
(d) $enAv_{Cl}$
(e) zero

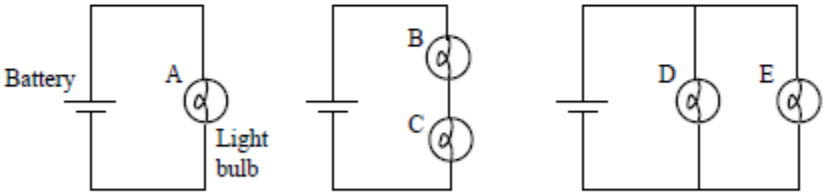
A student has set up the three circuits shown. The light bulbs and the batteries are identical.



→ **Q10** Rank all 3 ammeters (A_1, A_2, and A_3) in order of their current measurements from greatest to smallest.

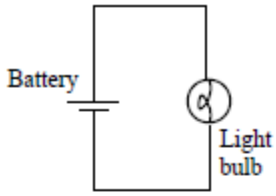
(a) $A_1 = A_2 = A_3$
(b) $A_1 = A_2 > A_3$
(c) $A_1 = A_3 > A_2$
(d) $A_2 = A_1 > A_3$
(e) $A_2 = A_3 > A_1$
(f) $A_3 > A_1 = A_2$
(g) $A_3 > A_1 > A_2$
(h) $A_3 > A_2 > A_1$
(i) None of the above

In these three circuits, all the batteries are identical and have negligible internal resistance, and all the light bulbs are identical.



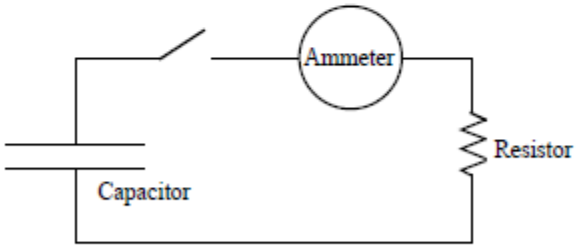
→ **Q11** Rank all 5 light bulbs (A, B, C, D, E) in order of brightness from brightest to dimmest.

(a) A = B = C > D = E
(b) A > B = C = D = E
(c) A > B = C > D = E
(d) A > B > C > D = E
(e) A = D = E > B = C
(f) A = D = E > B > C
(g) A > D = E > B = C
(h) D = E > A > B = C
(i) None of the above



→ **Q12** Which of the following statements is true about the electric field inside the bulb filament?

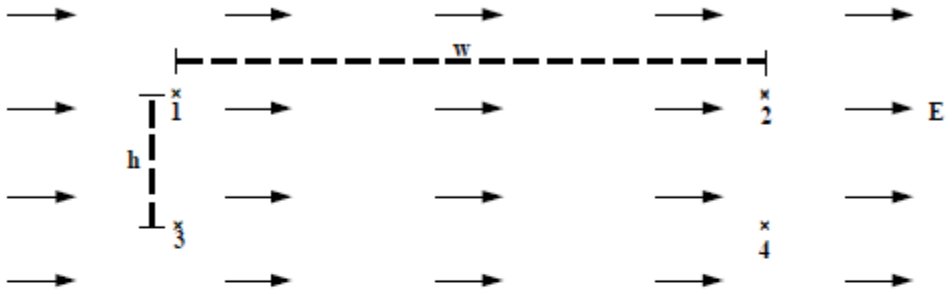
(a) The field must be zero because the filament is made of metal.
(b) The field must be zero because a current is flowing.
(c) The field must be zero because any excess charges are on the surface of the filament.
(d) The field must be non-zero because the flowing current produces an electric field.
(e) The field must be non-zero because no current will flow without an applied field.
(f) The field must be zero for reasons not given above.
(g) The field must be non-zero for reasons not given above.



→ **Q13** The capacitor is originally charged. How does the current I in the ammeter behave as a function of time after the switch is closed?

(a) $I = 0$ always.
(b) $I = \text{constant} \neq 0$
(c) I increases, then is constant.
(d) I instantly jumps up, then slowly decreases.
(e) None of the above.

In a certain region of space there is a uniform electric field of magnitude E:



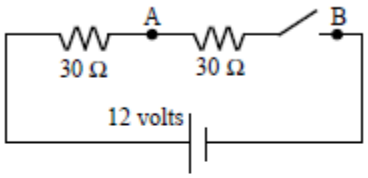
Choose from the following possible values to answer the three questions below:

(a) +Ew
(b) –Ew
(c) +Eh
(d) –Eh
(e) $+E\sqrt{(h^2+w^2)}$
(f) $-E\sqrt{(h^2+w^2)}$
(g) zero

→ **Q14** The potential difference $V_2 - V_1 = ?$

→ **Q15** The potential difference $V_3 - V_1 = ?$

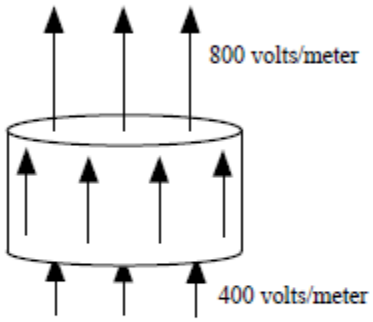
→ **Q16** The potential difference $V_4 - V_1 = ?$



→ **Q17** What is the magnitude of the potential difference between points A and B on the circuit, while the switch is open?

(a) 0 volts.
(b) 3 volts.
(c) 6 volts.
(d) 12 volts.
(e) None of the above.

Here is a cylinder on whose surfaces there is a vertical electric field of varying magnitude as shown. The electric field is uniform on the top face, and also uniform on the bottom face.



→ **Q18** This cylinder encloses

(a) no net charge.

(b) net positive charge.

(c) net negative charge.

(d) There is not enough information available to determine whether or not there is net charge inside the cylinder.

→ **Q19** In static equilibrium, the potential difference between two points inside a solid piece of metal

(a) is zero because metals block electric interactions.

(b) is zero because the electric field is zero inside the metal.

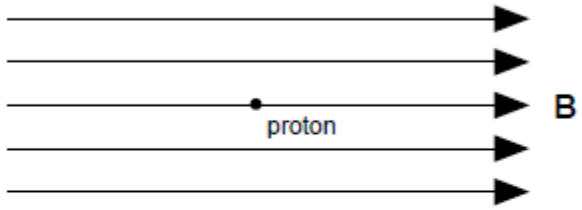
(c) is non-zero if the piece of metal is not spherical.

(d) is non-zero if there are charges on the surface of the metal.

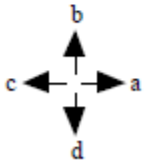
(e) is non-zero for reasons not given above.

(f) is zero for reasons not given above.

A proton is initially at rest in a region of constant magnetic field (shown below). There are no other charges present.



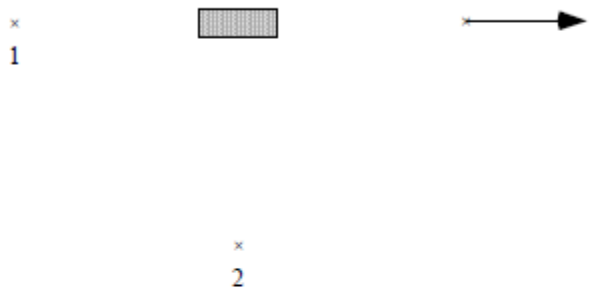
Choose from the following possible directions to answer the question below:



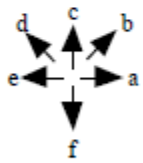
⊙ out of page	e
⊗ into page	f
zero force	g
none of the above	h

→ **Q20** What is the direction (a-h) of the initial magnetic force on the proton?

Here is a bar magnet. The magnetic field made by the bar magnet at one location is shown on the diagram:



Choose from the following possible directions to answer the questions below:



⊙ out of page g

⊗ into page h

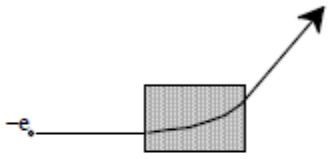
zero magnitude i

None of the above j

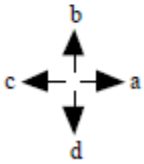
→ **Q21** What is the direction (a-j) of the magnetic field of the bar magnet at location 1 (marked with ×)?

→ **Q22** What is the direction (a-j) of the magnetic field of the bar magnet at location 2 (marked with ×)?

A moving electron travels along the path shown, and passes through a region of magnetic field. There are no other charges present. The magnetic field is zero everywhere except in the gray region.



Choose from the following possible directions to answer the question below:



⊙ out of page e

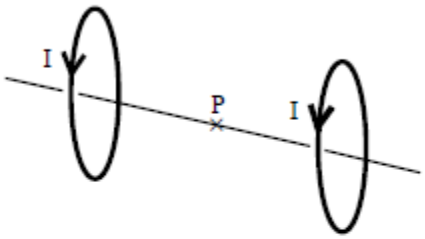
⊗ into page f

None of the above g

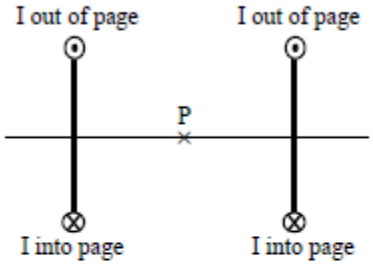
→ **Q23** What is a possible direction (a-g) of the magnetic field in the region where the field is non-zero?

Two identical circular loops of wire, perpendicular to the page, carry the same conventional current I:

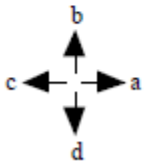
Perspective view



Front view



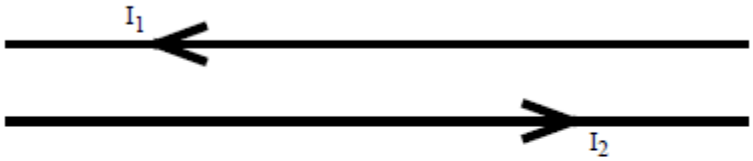
Choose from the following possible directions to answer the question below:



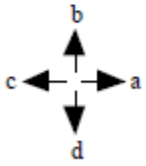
⊙ out of page	e
⊗ into page	f
zero magnitude	g
none of the above	h

→ **Q24** In the front view, what is the direction (a-h) of the magnetic field due to the loops at location P, midway between the loops?

Two wires lie in the plane of the page. Wire 1 carries conventional current to the left, and wire 2 carries conventional current to the right:



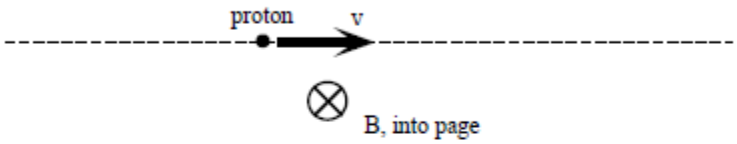
Choose from the following possible directions to answer the question below:



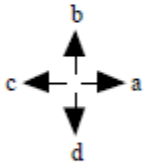
⊙ out of page	e
⊗ into page	f
zero magnitude	g
none of the above	h

→ **Q25** What is the direction (a-h) of the magnetic force that wire 1 exerts on wire 2?

A proton moves with constant velocity v to the right through a region where there is a uniform magnetic field of magnitude B that points into the page. There is also an electric field in this region. The magnetic field and electric field are produced by devices not shown on the diagram.



Choose from the following possible directions to answer the question below:



⊙ out of page e

⊗ into page f

None of the above g

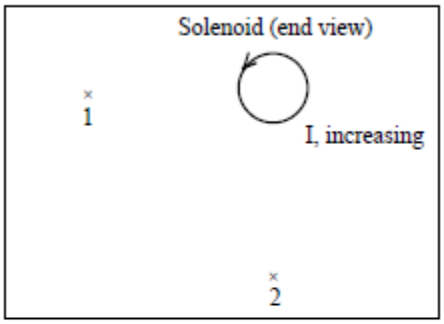
→ **Q26** What is the direction (a-g) of the electric field in this region?

→ **Q27** What is the magnitude of the electric field?

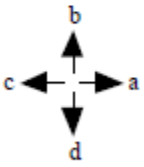
(a) evB
(b) $\vec{v} \times \vec{B}$
(c) vB
(d) B
(e) $e\vec{v} \times \vec{B}$
(f) vB/e
(g) ev
(h) None of the above

Here is a long solenoid (coils of wire along a long cylinder), and an end view of the solenoid. Conventional current runs counter-clockwise in the solenoid and is increasing with time.

Long solenoid, perspective view



Choose from the following possible directions to answer the questions below:

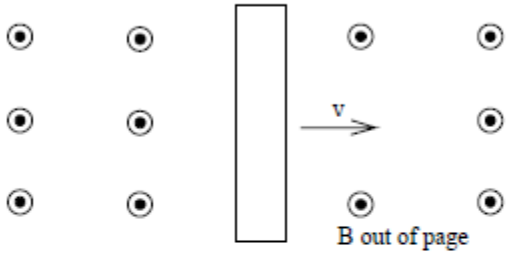


⊙ out of page	e
⊗ into page	f
zero magnitude	g
none of the above	h

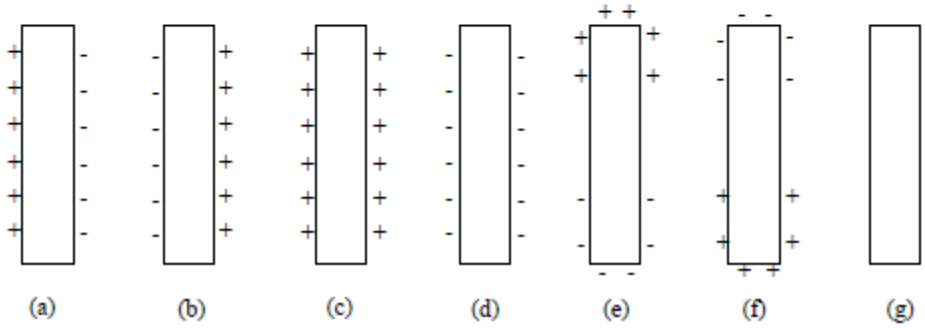
→ **Q28** What is the direction (a-h) of the *electric* field at location 1 (marked with an ×)?

→ **Q29** What is the direction (a-h) of the *electric* field at location 2 (marked with an ×)?

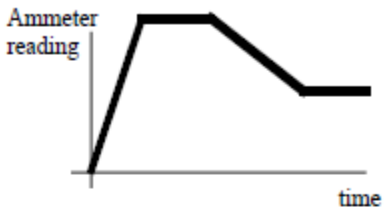
A neutral metal bar is moving at constant velocity v to the right through a region where there is a uniform magnetic field pointing out of the page. The magnetic field is produced by some large coils which are not shown on the diagram.

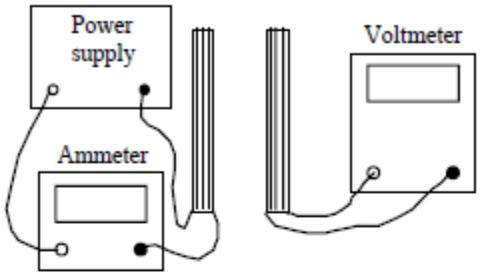


→ **Q30** Which of the following diagrams best describes the state of the metal bar?

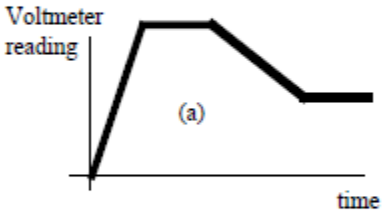


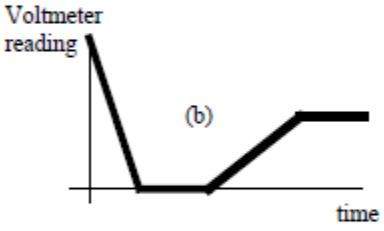
A variable power supply is connected to a coil and an ammeter, and the time dependence of the ammeter reading is shown. A nearby coil is connected to a voltmeter.

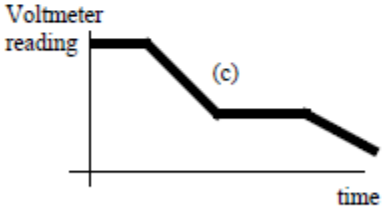


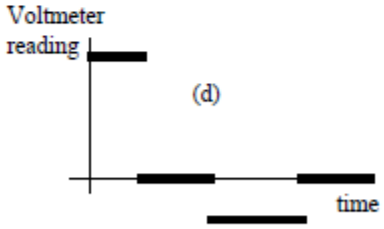


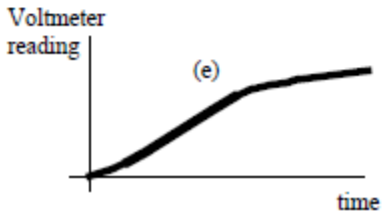
→Q31 Which of the following graphs correctly shows the time dependence of the voltmeter reading?

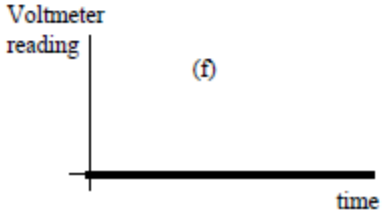












APPENDIX F

INSTITUTIONAL REVIEW BOARD EXEMPTION

MONTANA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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c/o Immunology & Infectious Diseases
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Chair: Mark Quinn
406-994-5721
mquinn@montana.edu
Administrator:
Cheryl Johnson
406-994-6783
cherylj@montana.edu

MEMORANDUM

TO: Benjamin Spicer and Walter Woolbaugh

FROM: Mark Quinn, Chair Mark Quinn CH

DATE: April 20, 2016

RE: *"A Case Study on the Impact of Massive Open Online Courses as Enrichment in Secondary Science and Mathematics Education" [BS042016-EX]*

The above research, described in your submission of April 20, 2016, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

_____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

SUBJECT ASSENT FORM FOR PARTICIPATION IN HUMAN RESEARCH

Principal Investigator: Benjamin T. Spicer Department: Sewickley Academy Senior School Science

Contact Person: In the event you have any questions about this research, you should contact Mr. Benjamin Spicer at bspicer@sewickley.org

Study Title: A Study of the Impact of Massive Open Online Courses as Enrichment in Secondary Science and Mathematics Education

Purpose: You are being asked to participate in a research study about your experiences and outcomes in a Massive Open Online Course (MOOC). This study seeks to understand the impact of using a MOOC in independent study courses for motivated high school students. This information will help improve the Independent Study experience. Results of general interest may be shared with the academic community.

Description of Procedure: Participation is voluntary. If you agree to participate you will be asked to participate in interviews and complete written surveys. Participation is voluntary and you can choose to not answer any questions you do not want to answer and/or you can stop at any time. Your participation or non-participation will not affect your grade or class standing.

By printing your name and signing the form on the next page, you consent to allow information collected by surveys given before, during, and at the end of the course to be used for this research. You also consent to receive follow-up emails and short surveys about your current attitudes about MOOCs into the following academic year. Interviews will take place face-to-face with Mr. Spicer in confidence. Surveys will be administered in written format. Every effort will be made to keep all communications private and anonymous. You also consent to allowing the use of results from standardized diagnostic assessments administered in written format to be used for this research. Although general data will be compiled, the individual assessments will be destroyed to protect your privacy. Again, participation is voluntary and you can choose to not answer any questions you do not want to answer and/or you can stop at any time. Your participation or non-participation will not affect your grade or class standing.

Discomforts: There are no known risks associated with participating in this study. **Alternatives**: You do not have to participate in this study. **Benefits**: The knowledge gained from this study may eventually benefit others. **Financial Considerations**: There are no fees associated with or compensation for this research.

Confidentiality: I promise that anything I learn about you in this study will be kept as secret as possible.

Voluntary Participation: You do not have to do this. No one will be angry with you if you refuse to do this or if you decide to quit. You have been allowed to ask questions about the research, and all of your questions were answered.

I willingly agree to be in this research.

Signatures

Signature of Subject

_____

Printed Name Date Time

_____

The minor has had the opportunity to have questions addressed. The minor willingly agrees to be in the study.

Signature of Investigator

_____

Printed Name Date Time

_____

PARENT/GUARDIAN CONSENT FORM FOR PARTICIPATION IN HUMAN RESEARCH

Principal Investigator: Benjamin T. Spicer Department: Sewickley Academy Senior School Science

Contact Person: In the event you have any questions about this research, you should contact Mr. Benjamin Spicer at bspicer@sewickley.org

Study Title: A Study of the Impact of Massive Open Online Courses as Enrichment in Secondary Science and Mathematics Education

Purpose: Your dependent child is being asked to participate in a research study about his/her experiences and outcomes in a Massive Open Online Course (MOOC). This study seeks to understand the impact of using a MOOC in independent study courses for motivated high school students. This information will help improve the Independent Study experience. Results of general interest may be shared with the academic community.

Description of Procedure: Participation is voluntary. If you agree to allow your child to participate he/she will be asked to engage in interviews and complete written surveys. Participation is voluntary and he/she can choose to not answer any questions he/she does not want to answer and/or he/she can stop at any time. Your participation or non-participation will not affect your child's grade or class standing.

By printing your name and signing the form on the next page, you consent to allow information about your child collected by surveys given before, during, and at the end of the course to be used for this research. You also consent to allow your child to receive follow-up emails and short surveys about his/her current attitudes about MOOCs into the following academic year. Interviews will take place face-to-face with Mr. Spicer in confidence. Surveys will be administered in written format. Every effort will be made to keep all communications private and anonymous. You also consent to allowing the use of results from your child's standardized diagnostic assessments administered in written format to be used for this research. Although general data will be compiled, the individual assessments will be destroyed to protect your child's privacy. Again, participation is voluntary and your child can choose to not answer any questions he/she does not want to answer and/or can stop at any time. Your participation or non-participation will not affect your child's grade or class standing.

Discomforts: There are no known risks associated with participating in this study. **Alternatives**: You do not have to participate in this study. **Benefits**: The knowledge gained from this study may eventually benefit others. **Financial Considerations**: There are no fees associated with or compensation for this research.

Confidentiality: Any information about your child that is obtained as a result of your participation in this research will be kept confidential. Once the complete dataset is collected, your child will be assigned an ID number, and all personal identifying information will be removed from the dataset. Any electronic information will be stored under this ID. Only Mr. Spicer will be able to access to the ID and any personal identifying information.

Voluntary Participation: Participation in this study is voluntary. You are free to withdraw your consent for your child to participate in this study at any time. Your child is free to remove his or her consent to participate at any time. Refusal to participate will involve no penalty to your child. Refusal to participate or withdrawal from the study will not affect your child's grades or eligibility to participate in any other class activities.

AUTHORIZATION: I have read the above and understand the discomforts, inconvenience and risk of this study. I, _____ (name of parent or guardian), related to the subject as _____ (relationship), agree to the participation of _____ (name of subject) in this research. I understand that the subject or I may later refuse participation in this research and that the subject, through his/her own action or mine, may withdraw from the research study at any time. I have received a copy of this consent form for my own records.

Signatures

Signature of Parent or Guardian

_____

Printed Name Date Time

_____

My child appears to understand the research to the best of his or her ability and had agreed to participate.

Signature of Investigator

_____

Printed Name Date Time

_____