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Flipped Classrooms for Advanced Science Courses

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Abstract This article explains how issues regarding dual credit and Advanced Placement high school science courses could be mitigated via a flipped classroom instructional model. The need for advanced high school courses will be examined initially, followed by an analysis of advanced science courses and the reform they are experiencing. Finally, it will conclude with an explanation of flipped classes as well as how they may be a solution to the reform challenges teachers are experiencing as they seek to incorporate more inquiry-based activities.

Keywords Flipped classroom · Advanced science courses · AP science · Dual credit

There is a direct correlation between the successful completion of advanced-level high school courses and college completion (Jones 2014; An 2013b). As society moves toward more knowledge-based employment opportunities, college degrees become more important for employability than ever before (US Bureau of Labor Statistics 2013; Moss and Tolly 2003). However, only slightly more than half the students who enter post-secondary school complete a baccalaureate within 6 years (National Center for Education Statistics 2013; Adelman 2006). It has also been shown that students who participate in advanced college preparatory courses in high school have a greater proclivity of success in college (Willingham and Morris 1986; Andrews and Barnett 2002; Allen and Dadgar 2012). Therefore, it could be extrapolated that students should be encouraged to enroll and successfully complete advanced courses to enhance their chances of collegiate degree completion through acquisition of skills necessary for academic success in post-secondary academic success (Bailey and Karp 2003; Watt et al. 2011).

Additionally, high school science instructors have been encouraged to increase the amount of inquiry in their classes in the hopes of enhancing their students' scientific literacy (National Research Council 2000). This requires teachers to expand the laboratory component of the course, but with the curriculum already at capacity, classroom time may be an issue when attempting to accomplish both inquiry and content coverage (Cooper and Klymkowsky 2013; Teo and Osborne 2012). This has been especially evident in Advanced Placement (AP) and dual credit courses (Parker et al. 2011; Fielding 2012).

AP and dual credit courses are designed to allow academically advanced high school students an opportunity to earn collegiate credit while still in secondary school (Nugent and Karnes 2002; Jones 2014; The College Board 2014b). With various authorities, such as politicians or school administrators (Schneider 2011; Lacey 2010), encouraging advanced courses combined with the additional time requirement for inquiry activities (National Research Council 2000, 2002), some educators started seeking for solutions outside of the standard classroom. Teachers have started to experiment with a new instructional method known as the "flipped classroom" to alleviate this issue. The flipped classroom may be a feasible solution to increase the time-consuming efforts of inquiry without sacrificing more direct dissemination of content (Tucker 2012; Deslauriers et al. 2011).

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This article explains how issues regarding dual credit and Advanced Placement high school science courses could be mitigated via a flipped classroom instructional model. The need for advanced high school courses will be examined initially, followed by an analysis of advanced science courses and the reform they are experiencing. Finally, it will conclude with an explanation of flipped classes as well as how they may be a solution to the reform challenges teachers are experiencing as they seek to incorporate more inquiry-based activities.

Advanced Courses and College Success

According to the National Center for Educational Statistics (2013), the unemployment rate for Americans with at least a bachelor's degree was lower than those without a degree. In the global economy, potential employers tend to favor highly educated individuals (Moss and Tolly 2003; US Bureau of Labor Statistics 2013). However, the completion rate for post-secondary school enrollees could be improved (Adelman 2006; Conley 2005; Bound et al. 2010). This section will demonstrate the need for high school students to academically challenge themselves in advanced courses to ease their matriculation and improve their chances of successfully earning a college degree.

Although currently approximately 68 % of high school graduates proceed directly to college (National Center for Education Statistics 2013), only a fraction of these enrollees achieve a bachelor's degree within 6 years (Adelman 2006; Heckman and LaFontaine 2008; Bound et al. 2010). According to Adelman, only one-third of the students who enter a 4-year college directly from high school complete a bachelor's degree within the given 4 years. Of the students who enter college, 54–58 % of the students will earn their bachelor's degree within 6 years (Adelman 2006). Numerous studies suggest that an increase in the availability and completion of advanced high school courses, which address critical thinking and problem solving skills, could ameliorate the issue (Allen and Dadgar 2012; An 2013b; McKillip and Rawls 2013). Contrary to the dropout rates, the students who complete Advanced Placement high school courses have a higher rate of collegiate success (Willingham and Morris 1986; Andrews and Barnett 2002).

The four primary avenues a student could pursue to obtain college credit while still in high school are to (1) successfully complete an AP course offered through The College Board (2014b), (2) successfully complete an International Baccalaureate course offered through the International Baccalaureate Organization (International Baccalaureate Organization, n.d.), (3) receive both high school and college credit for successful completion of a college course offered on a high school campus, and (4) travel to a college campus that allows high school students to enroll (Nugent and Karnes 2002; Jones 2014; Parker et al. 2013). These approaches tend to blur the lines between high school and college, easing the matriculation from one to the other (Karp et al. 2005; Andrews and Barnett 2002). Each of these programs provides a rigorous presentation of collegiate material (Nugent and Karnes 2002; Edwards et al. 2011). The availability of these courses is exploding throughout the country (Santoli 2002; Jackson 2010; Young et al. 2013) as colleges around the USA provide extra consideration to students who challenged themselves by attempting the AP and/or dual credit courses (Santoli 2002; Hebel 1999). This paper focuses on AP and dual credit courses, as these are the most common methods of earning college credit while still in high school (Nugent and Karnes 2002).

Some researchers suggest that students who are enrolled in AP and dual credit courses would have an innate propensity to succeed in college because participating students are those who are more determined to succeed and who potentially possess a greater ability for depth of understanding of college-level material (McKillip and Rawls 2013; Dougherty et al. 2006). Furthermore, students who were more intrinsically motivated to participate in science classes tended to achieve greater success in their introductory science courses as well as enroll in Advanced Placement science courses (Bryan et al. 2011). Therefore, if the students are self-selecting to participate in the advanced courses, it could be argued that research studies that analyze collegiate success as it correlates with advanced course completion could be skewed by these assumptions.

If the students are permitted to take advanced courses regardless of prerequisite qualifications, they may not be as prepared for the class regardless of their academic drive. There is a correlation between AP exam scores and preparedness of the student. The students who are less prepared for the rigor of the class tend to achieve lower scores on the exam (McKillip and Rawls 2013; Dougherty et al. 2006). Additionally, when SAT scores of those who participate in AP courses were compared, the researchers observed a direct correlation between AP exam scores and SAT scores. The research showed that students who scored 1 or 2 on the AP exam (lowest scores achievable) experienced little to no gain in SAT scores after completion of the course (McKillip and Rawls 2013).

However, many researchers noticed positive effects in college, regardless of the AP exam score earned. For instance, Scott et al. (2010) found that former AP students' first-semester college GPAs were consistently greater than the GPAs of their respective counterparts (i.e., similar SATs, socioeconomic status) who had not participated in

AP courses. Other researchers have found similar results with both AP courses and dual credit (Mattern et al. 2009; Smith 2007; Crouse and Allen 2014; Dougherty et al. 2006). Many indicate that the higher expectations incorporated into advanced courses do more than deliver content to the students; the courses also supply students with problem solving and critical thinking skills and teach the students appropriate studying habits (An 2013a; Henry 1990; Willingham and Morris 1986). The rigor and preparation that students receive in secondary school could have an effect upon future collegiate success (Watt et al. 2011; Bailey and Karp 2003; McKillip and Rawls 2013; Willingham and Morris 1986). Therefore, schools have been encouraged by governmental authorities to expand programs that incorporate more rigorous courses, such as Advanced Placement and Dual Enrollment (An 2013b; Schneider 2011; Lacey 2010; Karp et al. 2005).

In addition to learning content at a more sophisticated level, students can also potentially earn college credit for the successful completion of advanced courses while they are still in high school. This once again assists with the goal of collegiate degree completion and ultimately enhanced employability (Austin-King et al. 2012; Eimers and Mullen 2003; The College Board 2014e). Parents and students who participate in advanced courses in high school for college credit indicated several reasons to partake in the opportunity. Some participants believed that it was more cost-effective, while others believed that the additional college credits would allow them to graduate from the post-secondary institution in a more timely manner (Austin-King et al. 2012; Eimers and Mullen 2003; Santoli 2002; Young et al. 2013). Some students noted that they enjoyed the opportunity to learn from the "best" teachers in the school (Casserly 1986; Santoli 2002). Other students simply "feel" more prepared for college after completing the courses (Casserly 1986; Eimers and Mullen 2003). As noted, there are several different academically rigorous options available to students at the secondary level, which will be explored in greater detail next.

Advanced Placement and Dual Credit Science Courses

Of the many opportunities available to students wishing to achieve college credit while still in secondary school, Advanced Placement and dual credit are among the most prevalent. However, when examined in greater detail, several challenges arise. Many of these may be alleviated by the flipped classroom model, which is detailed later in the article. For instance, while determining whether a course is accepted into the dual credit program, many analyses must be completed. While both options potentially analyze the subject matter during the approval process, the dual credit courses also often examine the time spent in the class.

According to the College Board (2012, 2014b, c), AP chemistry, biology, and physics courses are considered to be the equivalent of a two-semester corresponding introductory course while an AP environmental science course is equivalent to a one-semester college course. AP exams are administered every May to determine the summative knowledge of the students. The scores from these exams can then be submitted to universities, who then determine whether college credit would be granted to the student for the score earned (The College Board 2014d). The majority of competitive schools require AP exam scores of a four or five, the highest scores available, in order to award college credit (Ganeshananthan 2000; Curry et al. 1999; Viadero 2000). It should be noted that, while more students are taking AP exams, there are also a greater number who are earning a 3 or lower on these exams (Jackson 2010). Consequently, there is the question of whether the AP courses are not requiring adequate rigor or whether students admitted to the courses are ill-prepared for the challenge (Jackson 2010).

Alternatively, post-secondary institutions and high schools are partnering to provide opportunities where students receive college credit while attending college-level classes in secondary school (Edwards et al. 2011; Burns and Lewis 2000; Andrews 2001). These courses are most often referred to as dual credit or dual enrollment terms that are frequently used interchangeably (Burns and Lewis 2000; Bailey and Karp 2003). Although few researchers have attempted to delineate the terminology (Burns and Lewis 2000; Bailey and Karp 2003), the ultimate outcome is the attainment of both high school and college credit for coursework done while in high school (Fontenot 2003; Burns and Lewis 2000).

While participating in these programs, students enroll in college-level courses at their current high school and the high school teacher instructs the course following a syllabus that was agreed upon with the partnering post-secondary institution (Edwards et al. 2011; Drummond 2013). This method is gaining great momentum in availability throughout the USA (Edwards et al. 2011; Allen and Dadgar 2012; Andrews 2001). Alternatively, the student may choose to attend a collegiate course on the college campus to earn both high school and collegiate credit (Edwards et al. 2011). Although these courses are not without issues (Drummond 2012; Fontenot 2003; Andrews and Barnett 2002), it has been shown that if the corresponding schools have a productive partnership, the results can be beneficial to the students while in high school as well as after graduation (Crouse and Allen 2014; Jones 2014; An 2013b).

The College Board prescribes the precise curriculum that is to be presented throughout the school year, while the dual credit reviews not only the content, but sometimes the contact hours as well. For instance, if a high school class would like to be considered for dual credit in general chemistry, the cooperating school may choose to look at the time spent in class in addition to the content, weighting of the grade and rigor of the exams. In this example, it is possible that the collegiate course is 3 h of lecture and 3 h of laboratory time per week. This equates to 6 h a week. However, in a high school setting, the teachers may only have 5 h at most a week, excluding snow days, fire drills, etc., to spend with their students. Thus, the high school teacher and cooperating university must find a way to make up for that extra hour a week. Fortunately, the high school academic year is often longer than a post-secondary institution. However, this is often not enough of a difference, and more time is still needed to match the actual time with students. Although there are several methods to augment the time for student–teacher interaction, such as extending laboratory time to include time before or after the scheduled school day, this paper focuses on extending the school day by presenting some material at home via the internet and lecture tutorials.

Not only are these programs helping the students become more prepared for collegiate challenges, but in some areas they are also improving the holistic science programs within the partnering high school (Zhai et al. 2013; Edwards et al. 2011). According to Zhai et al. (2013), several high schools have improved their geosciences programs through the integral involvement of the local colleges with the dual credit programs. Additionally, many colleges are taking advantage of the dual credit programs to promote STEM (science, technology, engineering, and mathematics) career opportunities and thus increasing the number of students planning to major in these areas for their post-secondary education (Ebert 2013; Zhai et al. 2013; Edwards et al. 2011).

Science Reform

Teaching college-level material in the secondary education environment presents a challenge due the extensive amount of material covered in a limited amount of time (Cooper and Klymkowsky 2013; Parker et al. 2011). Combine this with the laboratory requirements to fulfill (National Research Council 2002), time is of the essence. Some argue the need for even more laboratory time via scientific inquiry experiments (National Research Council 1999, 2000, 2002; Derting and Ebert-May 2010). Consequently, the flipped classroom model may be an attractive solution.

There has been a pronounced movement in science education to include more inquiry-based laboratory experiments that provide constructivist activities where the students explore and analyze data as practicing scientists would (National Research Council 1999, 2000). It is the National Research Council's (2002) stance that by allowing students to develop a more conceptual understanding of the sciences, they will then develop a deeper understanding of the content (Derting and Ebert-May 2010; Ermeling 2010). In the inquiry process, students actively participate in learner-led scientific investigations where they collaborate and review evidence to support their findings and then share their explanations of the phenomenon they experienced with others (National Research Council 2000). This method is aimed to improve scientific literacy among students, defined by the National Research Council (1998, p. 14) as "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs and economic productivity."

As an example of the inquiry-based instructional research performed, Deslauriers et al. (2011) studied the effects of implementing a constructivist-based activities classroom in an introductory collegiate physics course. The researchers performed a comparative study of two introductory physics courses. The control group ($N = 267$) followed a traditional lecture-based method that included a recitation. The experimental group ($N = 271$) required students to read 4–5 pages of information and complete an online assignment or quiz prior to class. Then the class time was utilized for high-order thinking collaborative problem solving.

The researchers found that the ability to increase the individualized attention during scheduled class time allowed the instructors to pose more complex problems to students and allowed the learners to work in small groups to analyze the questions. Deslauriers, Schelew, and Wieman believed that the students were then able to "practice physicist-like reasoning," which is an objective of scientific inquiry (National Research Council 2000). Throughout the semester, the researchers observed higher attendance levels as well as engagement in comparison with the traditional lecture format. Therefore, the instructors were able to maintain the current level of content while including more of the inquiry process in the regular class (Deslauriers et al. 2011).

Despite the initiative to augment science classes with inquiry, there has been a significant resistance to changing the teaching methods. Although many teachers indicate that they would like to add more inquiry into their classrooms, few are succeeding in this desire (Teo and Osborne 2012; Bishop and Verleger 2013; Breslyn and McGinnis 2012). A chief concern is the time associated with the process as well as the high-stakes summative end of course exams that are becoming more prevalent in the schools (Teo and Osborne 2012; Stieff 2011; Fielding 2012). The issue of balancing inquiry activities and content coverage within the allotted time constraints has shown to be an issue within both Advanced Placement and Dual Credit courses (Parker et al. 2011; Stieff 2011).

Historically, the quantity of content embedded into the high-stakes summative exam of the AP sciences leaves little room for a true inquiry process (Parker et al. 2013; Fielding 2012). According to the National Research Council (2000), the time allotted for inquiry should be lengthier anywhere from a couple of days for one project to allowing the students to work on a single project throughout the entire semester. The current, though evolving, science curriculum does not provide time to truly address the inquiry process (Cooper and Klymkowsky 2013). The current curriculum and teaching methods have been criticized for attempting to cover too much material in too short a time frame and failing to teach in a manner that reflects our current views of how individuals learn (Cooper and Klymkowsky 2013; Parker et al. 2011; Stieff 2011). Schools that have enhanced their AP courses with inquiry along with looping (the revisiting of prior content) found that their students achieved passing scores on the end of course assessment more regularly than schools that did not (Parker et al. 2013; Stieff 2011; Derting and Ebert-May 2010; Rushton 2012).

Cooper and Klymkowsky (2013) observed positive results when their general chemistry courses were adapted to cover fewer concepts but allowed for more review and reinforcement practices throughout the semester. Derting and Ebert-May (2010) studied the longitudinal effects of exposing students to a full-year introductory biology course that was inquiry-intensive. Their results showed that even the short exposure of two semesters produced the long-term effects of a deeper understanding of science and an ability to think more critically. Also, a change to a more collaborative and inquiry-based classroom may possibly motivate students to take more AP science courses (Bryan et al. 2011; Cooper and Klymkowsky 2013).

Bryan et al. (2011) conducted a study to examine the correlation of motivation, self-efficacy, and self-determination with a desire to complete an Advanced Placement science course in the future. The study consisted of 288 voluntary high school students between the ages of 14 and 16 (146 males, 146 females) in a primarily Caucasian (80.2 %) suburban high school. The participants were enrolled in either an introductory high school biology course or an introductory physical science course. The researchers observed that some students who were intrinsically motivated to pursue science did so as a result of the desire for collaborative learning opportunities. This could be extrapolated to argue that more inquiry may motivate more students to pursue science.

AP science courses are under critical evaluation due to the forced speed of content acquisition as a result of the quantity of content required to successfully complete the course, and some argue that this method sacrifices a students' depth of understanding (Parker et al. 2013; Russo 2000; Rushton 2012). As a result, the College Board has recently been restructuring the courses to provide more laboratory time, which includes inquiry, while focusing on main ideas rather than massive amounts of material with less exploration (The College Board 2012, 2014a). The Board visualizes the new AP science courses as including investigations that more closely mimic scientists' true experimentations along an inquiry continuum ranging from confirmation experiments through guided inquiry to ultimately an open investigation (White et al. 2014; Parker et al. 2013). There is a fear among some instructors that including inquiry into an already overwhelmingly large curriculum will neither be successful nor possible (Dove 2014). However, a recent development in educational methods may allow for STEM classes to include inquiry without sacrificing content. This is the flipped classroom model.

Flipped Classes

The flipped classroom model has the potential to alleviate some of the issues associated with Advanced Placement and dual credit courses (Bergmann and Sams 2008). First the model will be described in detail with several examples of its use. Later the application to Advanced Placement and dual credit courses will be explored.

A flipped classroom is a class structure in which the students receive the lecture material at home via screencasts, pre-recorded videos, or other dissemination techniques, and the scheduled class time is used more as a recitation format, where the students perform homework and in-depth collaborative assignments (Bergmann and Sams 2008; Margulieux et al. 2014). This technique has recently exploded as an experimental class structure to allow students more one-on-one time with the instructor and their peers to master difficult, higher-order thinking problems rather than struggling with the assigned practice problems at home without additional assistance. Many have started experimenting with this instructional method in the classroom from secondary schools (Bergmann and Sams 2008), to post-secondary schools (Findlay-Thompson and Mombourquette 2013; Love et al. 2013; Gray-Wilson 2013), and through graduate education (Tune et al. 2013; Pierce 2013).

The use of vodcasts and videos takes the possibility of flipped classroom further. Bergmann and Sams (2008) noticed that although the original motive for creating vodcasts and videos was to assist students who were absent from the chemistry class in which a topic was studied, other students who attended the class regularly took advantage of the videos. They realized that learners were watching and reviewing the videos to increase their own comprehension. As they discovered the students' perceived value of control of their own learning (being able to return to the videos and learn at their own speed), the instructors chose to pursue this concept further and assigned the videos to students to watch at home. These then became the homework while the homework then became the in-class work, hence the title "the flipped classroom." When they reflected upon the experience, they acknowledged that the quantity of individualized assistance for each student increased. The students who normally fell between the cracks were now receiving the help they required to succeed. Other researchers agree that the ability to rewind and review instructional videos could be one of the advantages of this instructional method (Love et al. 2013; Gray-Wilson 2013; Flumerfelt and Green 2013).

Several researchers believe that the ability for students to review these recorded lectures allowed for greater information retention in comparison with face-to-face lecture where students rely heavily on memory and personal notes (Wagner et al. 2013; Berrett 2012). Some researchers noted the availability of additional collaborative learning, individualized attention, and problem solving assistance by peers and the instructor during the scheduled class time were the primary cause of the greater learning achievements (Flumerfelt and Green 2013; Houston and Lin 2012; Fryenberg 2012).

Many other researchers found positive results within STEM courses (Boindala et al. 2013; Dove 2013). Love et al. (2013) studied the effects of flipping a linear algebra course for sophomore-level undergraduates. The study involved two sections of the course with one class utilizing the traditional method while the other utilized the flipped classroom model which included screencasts of the lecture material. The researchers examined content understanding and course perceptions. They found students involved in the flipped classroom performed better on sequential exams as well as held more positive perceptions of the course in general. The students made direct comments regarding their appreciation for the instructional video components.

These results are not isolated (Lage et al. 2000; Day and Foley 2006; Gray-Wilson 2013). For example, Wagner et al. (2013) participants in a flipped engineering course found the video recorded screencasts of the lecture information to be as useful, and often more useful, than the traditional face-to-face lecture. Furthermore, the students appreciated the in-class assignments to practice their problem solving techniques of the new content with their peers and instructor. Gray-Wilson (2013) was able to increase problem solving collaborations and real-life examples without sacrificing the quantity of content in her college-level statistics course for social science majors. She also noticed an improvement of the final grades among the participating students. In a comparative study that examined upper division engineering courses for 2 years, in which the first year was taught as a traditional lecture format and the second year was taught as a flipped classroom model, Mason et al. (2013) indicated that the instructors were able to cover more information while the students performed as well or better than the students in the traditional lecture format.

This new instructional method is not without its faults. Despite the positive results in learning outcomes, the perception of additional work may lead both students and instructors to be reluctant to adopt it. Some students have been resistant to adopt the flipped class structure as a result of added responsibilities in their preparation. However, most instructors do not view this negatively, but as a reluctance of the students' willingness to put forth the necessary efforts to succeed (Gray-Wilson 2013; Berrett 2012; Kachka 2012; Fryenberg 2012). Additionally, some instructors feel as though the time required preparing these online lectures is too demanding and daunting to consider the method a valuable use of their time (Berrett 2012; Cold 2013). A number of instructors have overcome the time commitment issue by assigning the videos to be produced by others, such as teaching assistants or students within the course as an assignment (Fryenberg 2012), while other instructors begin flipping their class by recording only a few lectures at a time (Cold 2013). Ultimately, the instructor of record is responsible for the integrity of the content and the course materials. If the instructor does choose to re-assign the tasks to either students or teaching assistants, it should be the instructors' responsibilities to review, modify, or even choose not to utilize videos.

When reviewing and editing videos, instructors should be mindful of the length of the video to enhance the efficacy of the tutorials. To create the most effective video lecture experience, instructors should be aware of the time allotted per video. The videos should be less than 20 min to be the most effective for student participation and content retention (Houston and Lin 2012; Wagner et al. 2013; Kachka 2012; Day and Foley 2006).

While it might be argued that lecture tutorials are simply the reiteration of the classroom lecture, the concept of just-in-time learning should be considered. While students, even those who attend lecture regularly, take the time to practice and reinforce their newfound knowledge, they may become confused and frustrated while tackling the problems alone. However, if the lecture tutorials are always available for access as needed and organized to reflect the course structure, the students know they are not alone in the learning process. As they become frustrated, they know they can refer to any number of lecture tutorials to re-explain the topic, should they need the additional assistance.

Furthermore, if the students begin to understand that additional support is available as they encounter complicated topics, they could potentially become more independent learners by learning to seek out questions independently rather than waiting for the next interaction with the instructor. Students may become better able to determine when they need help and not simply assume they will "pick it up later." In this process, the subject matter becomes more tailored to the students' educational needs. For instance, if the students, who ordinarily feel isolated studying at a desk, are then able to begin determining when they need help and the best way to receive assistance, then the students become more self-reliant and thus able to focus on areas that they truly need to practice.

Finally, the lecture tutorials allow for think aloud opportunities to explain the steps in solving problems. Instead of books providing a handful of examples that vaguely explain how to obtain the solution, a video can show step-by-step solutions supported with narration and annotations that explain the reasoning behind the steps. A video is more fluid and personal while the static written page may feel less expressive and incapable of explaining minuscule details, which may be difficult for students who struggle with science in general and those topics that contain a great deal of mathematical computations specifically.

Possible issues with reliable Internet access have also been an issue with such courses. Dual enrollment agreements occasionally rely heavily on the availability of Internet access as a result of implementing an online or hybrid version of the college course in the high school environment (White et al. 2014). Harris and Stovall (2013) had positive results with mathematics courses: college algebra, plane geometry, and statistics offered online to rural students who were unable to travel to the college campus. They found that the flexibility afforded with online courses was beneficial to high school students involved in extracurricular activities such as sports or employment. Availability of Internet access was among the issues encountered throughout the project; some Web sites were blocked by the school district, and some districts had issues with reliability of the Internet in general (Harris and Stovall 2013). Creating backup DVDs of the screencasts may be a possible solution to alleviate issues of reliability of the Internet while streaming videos (Kachka 2012).

Flipped Classes May be the Solution

The flipped classroom could potentially be a solution to several current problems faced by educators. It has the means to ease the time constraint issues in Advanced Placement and dual credit courses. Additionally, it may alleviate issues regarding teacher qualifications. Furthermore, it can also provide the additional time necessary to augment the STEM curriculum with inquiry experimental activities without sacrificing content.

Instructors who feel they may need more time in class to complete laboratory assignments and still have time to review and reinforce content may appreciate the flipped classroom. According to Bergmann and Sams (2008), the laboratory time could be augmented when the class is taught as a flipped classroom. If the lecture tutorials are available at home rather than in the classroom, not only will students have access to the material as they require additional assistance, but this will also alleviate extremely valuable classroom time for additional laboratory studies without sacrificing the content coverage. The teachers maintain the same amount of content covered, yet they are able to do so while not meeting face to face in the scheduled class time. The teachers could then potentially cover the material more quickly, thus leaving time for additional laboratory investigations and the time-consuming, in-depth inquiry projects, which is a goal of both The College Board and the National Science Standards. However, being such a recent development, this has yet to be empirically studied. The currently available research for flipped classrooms reflects collegiate courses, where laboratory time is separate from the lecture time. Therefore, researchers should consider experimentation of this method within the k-12 environment to determine whether this model actually does increase time allocated for laboratory assignments and inquiry activities.

Some researchers noticed more negative results regarding student attendance. Cold (2013) utilized the flipped classroom method with Process Oriented Guided Inquiry Learning (POGIL) for an instructional technology course. He noted the method allowed for more inquiry in the classroom. However, the instructor did note the attendance decreased as the information was available online rather than solely in class. Pierce (2013) also combined a POGIL-focused course utilizing the flipped classroom method with positive results. Unlike Cold (2013), Pierce (2013) required the attendance of all participants in the course. Conversely, it could be assumed that attendance would be less of an issue at the secondary level since students are legally required to attend class and attendance is recorded by each instructor on a daily basis.

Burns and Lewis (2000) studied the school climate and the student perceptions of dual credit courses when they surveyed students who attended dual credit courses in either a high school or college setting. They observed that students who attended the course in a college setting appeared to have a greater satisfaction level than those who were enrolled in similar courses on the high school campus. However, other studies have concluded that while courses on the college campus appeared to provide greater challenges and create a greater level of satisfaction, those students who attended the similar course on high school campuses tended to be more successful in the comprehension of the material (Bailey and Karp 2003; White et al. 2014). Furthermore, Karp et al. (2005) indicated that attending a dual credit course on a college campus is more beneficial, but they do concede that this requirement does limit the availability of the course. Therefore, although the student perception is one of greater accomplishment with the course completed on the collegiate campus, it may not always be a feasible option.

The low feasibility of the high school student travelling to the college campus opened the door to allowing secondary teachers to instruct the college-level course on their high school campus; however, there are concerns regarding the qualifications of the AP and Dual Credit instructors' among partnering colleges (Young et al. 2013; Drummond 2012; Fontenot 2003). High school teachers may not have a master's degree or additional education in the subject matter beyond their baccalaureate, which would be required if the instructor was conducting a course on a college campus (Santoli 2002; Karp et al. 2005). Therefore, although the student is receiving college credit, the instructor may not truly be qualified to teach a college course (Santoli 2002). In smaller, more rural schools, this issue may be even more likely as a result of instructors teaching multiple subjects and who, therefore, may not be qualified to teach specific dual credit courses or because of the distance the students would have to travel to attend a college course (D'Amico et al. 2013; Harris and Stovall 2013; Bragg et al. 2006).

While some colleges are resolving this problem by choosing to select and train those they believe to be qualified high school teachers to instruct the dual enrollment programs at the high schools (Zhai et al. 2013; Edwards et al. 2011; Karp et al. 2005), there could be another solution. In the flipped class scenario, the video lectures/screencasts are produced by the professors of the university providing the college credit; thus, the issues related to instructor qualifications may be alleviated (Harris and Stovall 2013). With this method, the high school teacher could potentially be viewed more as a teaching assistant or co-teacher of the course while the collegiate professor is the primary instructor.

In addition to the teacher qualifications, there is a great deal of concern as to whether the material in the dual credit course is truly the material that is taught on the college campus (Drummond 2012; Johnson and Brophy 2006; Fontenot 2003). While The College Board (2014b) dictates the precise content that is delivered to the students in AP courses with a summative exam at the end, there are fewer defined criteria for dual enrollment courses (Drummond 2012; Fontenot 2003; Karp et al. 2005). Therefore, colleges and universities who are participating in such programs must keep a watchful eye on the materials delivered in the agreed upon course (Drummond 2012; Edwards et al. 2011; Andrews and Barnett 2002). If a true partnership is created where the secondary and post-secondary schools work together to create the curriculum, there could be better alignment of the vertical curriculum as the learner progresses from high school to college (Allen 2010; An 2013b). If a course is offered in the flipped course method with the videos created directly from the professors who teach the course on the collegiate campus, this assures that the material is truly representative of the on-campus course. There is little to no variance among the courses if the videos are based upon standardized expectations of that particular college professor (Harris and Stovall 2013).

The flipped classroom model would allow instructors to harness the technological capabilities that we have available to best achieve our goals in the classroom (Bishop and Verleger 2013; Flumerfelt and Green 2013). Many believe the computer can build a more personal and individualized learning structure (Flumerfelt and Green 2013; Berrett 2012; Houston and Lin 2012). Courses offered with the inclusion of Internet-based resources, such as course management systems and/or screencasts where college professors are delivering the identical information of the courses that are offered on campus, could alleviate issues such as distance, unqualified instructors, or course content dissimilarities since it is a true replication of the college course (Harris and Stovall 2013).

Challenges to Consider

When attempting to move forward with this model, some possible pragmatic challenges may emerge. These involve both technology and user roadblocks. Therefore, we must pursue an onward strive with caution and with awareness of potential pitfalls. These concerns will be explored in this next section, starting with technology-based challenges and then continuing onto user-related barriers.

Technology Concerns

With technology expanding expeditiously, there are great concerns regarding access to the course management system, administrative rights and storage. For this project to be successful, not only does each high school instructor need access and ability to create their own course, 100 % of the students in the classroom must have access to the course Web site. In the majority of dual credit classrooms, even though everyone in the class is registered for the high school course, not all may be enrolled in the collegiate course. In other words, some students will be receiving high school credit while others are receiving both high school and college credit. This could create an issue with the availability of the materials of the course management system.

It would be nonsensical to require a high school teacher to utilize two methods for instructing the same class. If all the students do not have access to the course materials, then the classroom teacher would not be able to completely flip his or her class because some students will have access to the screencasts and other materials the university has made available while others did not. While there is still a benefit for those students enrolled in the collegiate course as they can use the materials as supplemental resources for the course, the teacher would not be able to assign the tutorials to the entire class and utilize them to potentially increase the laboratory component of the course and the individualized assistance of the learners.

If all the students were granted access to the course, administrative challenges may arise. While the students who are enrolled in the collegiate course may already possess usernames and passwords to access the course management system, a login would be needed for the additional students. This requires time to create the appropriate credentials for these learners. Roadblocks may appear from upper level administrators who do not wish for students not enrolled in the university to be allowed access to the course management system for security reasons.

Some of these challenges may be circumvented through other avenues, but in my opinion, it is not as ideal as maintaining the course on the university's Web site. For instance, there are course management systems that are available free of charge to educators that the teachers could then load the information. Although this is a feasible solution, there is a greater chance of unreliability with these sources. If there is an issue, how would the problem be resolved, outside of the teacher fixing it him or herself? Plus, the university may lose tracking and built-in assessment capabilities, which may be necessary for either research or accreditation purposes.

Another feasible solution would be even less secure, the cooperating university instructor could post his or her tutorial videos on an open source Web site, such as YouTube or TeacherTube for the high school teachers to access and assign to their students. Although this would make the videos readily available, the most accurate tracking capabilities would then be lost. However, it may be a solution for other challenges such as available memory on the course management system.

In many universities, the instructor is provided with a limited amount of memory space for his or her course. Videos, even short ones, use a relatively large amount of memory to house them. By placing these videos on YouTube and then linking them to the course management system and ultimately making the videos "private" so that only those with a direct link could access them, you save a great deal of memory. This space could then be utilized to load the PowerPoint slides that are used in the lecture tutorials. This would help the student organize their notes for easy reference in the future.

Also, while creating the PowerPoint slides and videos, it may be useful to not reference specific page numbers or table names in the tutorial. If this is done, the video would then need to be edited or even recreated each time a new edition of the textbook or a different textbook has been adopted. If your subject matter is such that the topics do not change much from textbook to textbook and only the way in which it is explained is altered, then it is very possible that the same videos may be used for multiple textbooks or courses. For instance, if an instructor teaches chemistry and must explain how to balance chemical equations, the actual step of balancing would be the same regardless of the textbook book that is used or the level of the course. Although some examples may be more difficult than others, the basic procedure would remain constant and so the same video may be used for multiple classes saving the instructor time in the future.

To assist with the video creation process further, if multiple instructors are all creating tutorials for their courses, perhaps a pool of university videos could then be accessed by others interested in utilizing the videos for similar purposes. An instructor may also be interested in searching other sites for videos to link to their courses by looking at TeacherTube or You Tube or some other video sharing Web site.

User Challenges

There may be reluctance from administrators, teachers, and students with this new educational method. Some administrators or educators may look at the new method as an intrusion of the university into the high school. Some students may object to the additional workload of the assigned videos.

Administrators and teachers must realize, as the new course structure is proposed, that the university is not attempting to circumvent their teacher. The teacher has an extremely active role in this new educational method. The flipped classroom could create a classroom that is more individualized for the student as well as increase the laboratory time. The educator may feel as though they are able to better understand their students while conducting their course in this manner. As the teachers are given more time to rotate around the classroom, they are able to see where their students are having difficulties and if there are any glaring issues. It is possible that the teachers appreciate the method even more than they thought they would because they may be able to relate to their students better than they could have perceived.

While some teachers may be reluctant because they feel as though they no longer have "academic freedom" over their classroom, others may be enthusiastic. An instructor or researcher could utilize these enthusiastic teachers as case studies to determine why they approached the model with such vigor. Perhaps they believe that they could get to know their students better, perhaps they believe that the students could understand the materials better with a constantly available resource, or perhaps they would be excited by the prospect of covering more material and adding more laboratory procedures. Time is always an essence in schools, so perhaps the teacher believes that the flipped classroom could assist with time management while precious minutes are taken from their instructional time with fire drills, teacher in-service days, or pep rallies. It is conceivable that the teachers could perceive the technology helping their students adjust to collegiate life in the future. As college course are becoming more and more augmented with technology, the educator may want to help prepare his or her students for this supplement to their post-secondary classes.

While some approaching this method may have educators who resist this change and those who may embrace the change, some teachers will simply not utilize it to its full potential without either negative or positive regard for the flipped classroom. Some teachers may view the tutorials as merely another supplement for the classes. They may decide to make the tutorials available to the learners, but not assign them. This could be for a variety of reasons. The educator may be reluctant to change, they may be concerned about the students' availability of high-speed internet at home or they may be concerned about the students' time to watch the videos. These are all pragmatic concerns that a dedicated teacher may possess.

Conclusion

There are many questions that need to be explored as we move forward in this project. For instance, is the time commitment of the students as relevant as the teachers believe or is it the students' procrastination causing the majority of the videos to be watched on the weekends? Are there additional underlying reasons for the teachers to resist the flipped classroom model, such as a reluctance to change their teaching method as a result of fear or complacency? Are there true positive effects shown with this method on the high school campus? Does it resolve the issues with dual credit that it is predicted to, with instructor qualifications, classroom time, or more in depth or speed of coverage? Would a particular student population benefit more from the experience than others? Some believe that this format could assist low-income or minority students to be successful in advanced courses by providing a more interactive learning experience. However, other authors believe that lower income students may lack the appropriate resources (i.e., computer, internet connection) to truly take advantage of this methodology (Horn 2013). More research is required to truly understand the impact of flipped classrooms in this context.

Several issues with advanced science courses exist, including the quantity of material embedded within the curriculum (Cooper and Klymkowsky 2013; Parker et al. 2013), the lack of necessary reform to include more inquiry in the classroom (National Research Council 2000), limited available time for exploratory inquiry methods (National Research Council 2000), and a lack of evidence that the course which high school students are receiving college credit for is truly representative of the corresponding college course (Drummond 2012; Fontenot 2003). This article described the flipped classroom, and how this instructional method could help alleviate these issues. The flipped classroom, with videos supplied by the partnering post-secondary institution, would able to offer the same instructor and content that is presented on that college campus (Harris and Stovall 2013), with the high school teacher's role being viewed as the college professor's partner rather than the sole instructor of the course. This also allows the high school teacher more time to increase individualized instruction (Bergmann and Sams 2008; Berrett 2012) as well as for increased inquiry (Bergmann and Sams 2008; Cold 2013). Flipped classrooms offer a strong potential solution for creating both academically challenging courses and increasing inquiry in science classrooms.

References

Adelman C (2006) The toolbox revisted: paths to degree completion from high school through college. U. S. Department of Education, Washington DC

Allen D (2010) A comprehensive literature review and bibliography. CUNY Collaborative Programs, New York

Allen D, Dadgar M (2012) Does dual enrollment increase students' success in college? Evidence from a quasi-experimental analysis

of dual enrollment in New York City. New Dir High Educ 158:11–19
An BP (2013a) The impact of dual enrollment on college degree attainment: do low-SES students benefit? Educ Eval Policy Anal 35(1):57–75
An BP (2013b) The influence of dual enrollment on academic performance and college readiness: differences by socioeconomic status. Res High Educ 54(4):407–432
Andrews H (2001) The dual-credit phenomenon! challenging secondary school students across 50 states. New Forums Press, Stillwater
Andrews H, Barnett E (2002) Dual credit/enrollment in Illinois a status report. Office of Community College Research and Leadership, Champaign. Retrieved from http://occrl.illinois.edu/files/InBrief/Brief-summer-02.pdf
Austin-King K, Lee PN, Little JA, Nathan J (2012) Progress and possibilities: trends in public high school student participation with Minnesota's Dual Credit Programs 2006–2011. Center for School Change at Macalester College, St. Paul
Bailey T, Karp MM (2003) Promoting college access and success: a review of credit- based transition programs. Office of Vocational and Adult Education, U.S. Department of Education, Washington, DC
Bergmann J, Sams A (2008) Remixing chemistry class: two Colorado teachers make vodcasts of their lectures to free up class time for hands-on activities. Learn Lead Technol 36:22–27
Berrett D (2012) How 'flipping' the classroom can improve the traditional lecture. Chron High Educ. Retrieved from http://moodle.technion.ac.il/file.php/1298/Announce/How_Flipping_the_Classroom_Can_Improve_the_Traditional_Lecture.pdf
Bishop J, Verleger M (2013) Testing the flipped classroom with model-eliciting activities and video lectures in a mid-level undergraduate engineering course. In: Frontiers in education conference. IEEE, Oklahoma City, OK, pp 161–163
Boindala PS, Brewley DN, Sinclair J, Erickson K (2013) The nuts and bolts of planning a "flipped" classroom in higher education. In: 33rd annual conference lilly conference on college and university teaching & learning. International Teaching Learning Cooperative, LLC, Oxford. Retrieved from http://www.et.kent.edu/fpdc-db/files/Boindala_etal_PropFlippingClassroom.pdf
Bound J, Lovenheim M, Turner S (2010) Why have college completion rates declined? An analysis of changing student preparation and collegiate resources. J Appl Econ 2(3):129–157
Bragg D, Kim E, Barnett E (2006) Creating access and success: academic pathways reaching underserved students. New Dir Commun Coll 135:5–19
Breslyn W, McGinnis JR (2012) A comparison of exemplary biology, chemistry, earth science, and physics teachers' conceptions and enactment of inquiry. Sci Educ 96(1):48–77
Bryan RR, Glynn SM, Kittleson JM (2011) Motivation, achievement, and Advanced Placement intent of high school students learning science. Sci Educ 95(6):1049–1065
Burns H, Lewis B (2000) Dual-enrolled students' perceptions of the effect of classroom environment on educational experience. Qual Rep 4(1 & 2). Retrieved from http://www.nova.edu/ssss/QR/QR4-1/burns.html
Casserly PL (1986) Advanced Placement revisited. College Entrance Examination Board, New York
Cold SJ (2013) Partially flipped: experiences using POGIL. 14th annual ACM SIGITE conference on Information technology education. Association for Computing Machinery, Orlando, pp 133–134
Conley D (2005) College knowledge: what it really takes for students to succeed and what we can do to get them ready. Jossey-Bass, San Francisco
Cooper M, Klymkowsky M (2013) Chemistry, life, the universe, and everything: a new approach to general chemistry, and a model for curriculum reform. J Chem Educ 90(9):1116–1122
Crouse J, Allen J (2014) College course grades for dual enrollment students. Commun Coll J Res Pract 38(6):494–511
Curry W, MacDonald W, Morgan R (1999) The Advanced Placement program: access to excellence. J Second Gift Educ 11(1):17–22
D'Amico MM, Morgan GB, Robertson S, Rivers HE (2013) Dual enrollment variables and college student persistence. Commun Coll J Res Pract 37(10):769–779
Day J, Foley J (2006) Evaluating a web lecture intervention in a human–computer interaction course. IEEE Trans Educ 49(4):420–431
Derting TL, Ebert-May D (2010) Learner-centered inquiry in undergraduate biology: positive relationships with long-term student achievement. CBE-Life Sci Educ 9(4):462–472
Deslauriers L, Schelew E, Wieman C (2011) Improving learning in a large-enrollment physics class. Science 332(6031):862–864
Dougherty C, Mellor L, Jian S (2006) The relationship between Advanced Placement and college graduation. National Center for Education Assessment 2005 AP Study Series, Report 1
Dove A (2013) Students' perceptions of learning in a flipped statistics class. In: McBride R, Searson M (eds) Proceedings of society for information technology & teacher education international conference 2013. Association for the Advancement of Computing in Education (AACE), Chesapeake, VA, pp 393–398. Retrieved May 20, 2015, from http://www.editlib.org/p/48133
Dove A (2014) Examining the influence of a flipped mathematics classroom on achievement. In: Conference on higher education pedagogy. Virginia Tech, Blacksburg, pp 251–252. Retrieved from http://www.cider.vt.edu/conference/proceedings/2014ConferenceProceedings.pdf
Drummond C (2012) Teaching college geology in high school: the concurrent challenges and opportunities of dual credit programs to departments of geology. Geological Society of America Annual Meeting. 44. The Geolgical Society of America, Charlotte, p 308
Drummond C (2013) Building and managing relationships with secondary schools through dual-credit collaborations. 125th anniversary annual meeting & expo. 45. Geological Society of America, Denver, p 431. Retrieved from https://gsa.confex.com/gsa/2013AM/finalprogram/abstract_226806.htm
Ebert J (2013) Fanning the flames of student interest: dual credit courses and recruitment of geoscience majors. 125th anniversary of geological society of America. 45. The Geological Society of America, Denver, p 432. Retrieved from https://gsa.confex.com/gsa/2013AM/finalprogram/abstract_233036.htm
Edwards L, Hughes KL, Weisberg A (2011) Different approaches to dual enrollment: understanding program features and their implications. Community College Research Center, New York
Eimers M, Mullen R (2003) Dual credit and advanced placement: do they help prepare students for success in college. 2002 MidAIR and 2003 AIR conference. Association for Institutional Research, Tampa
Ermeling B (2010) Tracing the effects of teacher inquiry on classroom practice. Teach Teach Educ 26(3):377–388
Fielding R (2012) Research supports value of updated school facilities. Educ Can 52(5). Retrieved from http://www.cea-ace.ca/education-canada/article/research-supports-value-updated-school-facilities
Findlay-Thompson S, Mombourquette P (2013) Evaluation of a flipped classroom in an undergraduate business course. Global conference on business & finance. 8. The Institute for Business & Finance Research, Las Vegas, p 138
Flumerfelt S, Green G (2013) Using lean in the flipped classroom for at risk students. Educ Technol Soc 16(1):356–366

Fontenot J (2003) Dual credit: raising the bar or lowering the standard?. Office of Community College Research and Leadership, Champaign

Fryenberg M (2012) Flipping excel. In: Proceedings of the information systems educators conference, vol 29. Education Special Interest Group of the AITP, New Orleans, pp 63–73. Retrieved from http://proc.isecon.org/2012/pdf/1914.pdf

Ganeshananthan VV (2000) AP program faces new criticism over its testing standards. Chron High Educ 46(45):45–46

Gray-Wilson S (2013) The flipped class: a method to address the challenges of an undergraduate statistics course. Teach Psychol 40(3):193–199

Harris RJ, Stovall ST (2013) Online dual credit mathematics for rural schools. Probl Resour Issues Math Undergrad Stud 23(5):434–440

Hebel S (1999) AP courses are new target in struggle over access to college in California. Chron High Educ 46(14):32–34

Heckman JJ, LaFontaine PA (2008) The declining American High School Graduation Rate: evidence, sources, and consequences. The National Bureau if Economic Research, Cambridge

Henry M (1990) A skill sequence for honors class in high school social studies. Soc Educ 54(1):46

Horn M (2013) The transformational potential of flipped classrooms. Educ Next 13(3):78–79

Houston M, Lin L (2012) Humanizing the classroom by flipping the homework versus lecture equation. Society for information technology & teacher education international conference 2012. AACE, Chesapeake, pp 1177–1182

International Baccalaureate Organization (n.d.) About the International Baccalaureate. Retrieved February 5, 2014, from http://www.ibo.org/general/who.cfm

Jackson CK (2010) A little now for a lot later: a look at a Texas advanced placement incentive program. J Hum Resour 45(3): 591–639

Johnson TE, Brophy M (2006) Dual enrollment: measuring factors for rural high school student participation. Rural Educ 28(1):25–32

Jones S (2014) Student participation in dual enrollment and college success. Commun Coll J Res Pract 38(1):24–37

Kachka P (2012) Understanding the flipped classroom: part 2. Faculty Focus. Retrieved from http://www.super-super.com/flipped/downloads/files/Flippedexample.pdf

Karp MM, Bailey T, Hughes K, Fermin B (2005) State dual enrollment policies: addressing access and quality report. Community College Research Center, New York. Retrieved from http://ccrc.tc.columbia.edu/publications/state-dual-enrollment-policies.html

Lacey T (2010) Access, rigor, and revenue in the history of the advanced placement program. In: Sadler P, Sonnert G, Tai R, Klopfenstein K (eds) AP: a critical examination of the advanced placement program. Harvard Education Press, Cambridge, pp 17–48

Lage MJ, Platt G, Treglia M (2000) Inverting the classroom: a gateway to creating an inclusive learning environment. J Econ Educ 31(1):30–43

Love B, Hodge A, Grandgenett N, Swift AW (2013) Student learning and perceptions in a flipped linear algebra course. Int J Math Educ Sci Technol. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/0020739X.2013.822582#.Uup5iPvfItU

Margulieux L, MrCracken WM, Bujak KR, Majerich D (2014) Hybrid, blended, flipped, and inverted: defining terms in a two dimensional taxonomy. Hawaii International Conference on Education (HICE). Honolulu, HI. Retrieved from http://c21u.gatech.edu/publications/hybrid-blended-flipped-and-inverted-defining-terms-two-dimensional-taxonomy

Mason GS, Shuman TR, Cook KE (2013) Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. IEEE Trans Educ 56(4):430–435

Mattern K, Shaw E, Xiong Y-H (2009) The relationship between AP exam performance and college outcomes. College Board, New York

McKillip ME, Rawls A (2013) A closer examination of the academic benefits of AP. J Educ Res 4:305–318

Moss P, Tolly C (2003) Stories employers tell: race, skill, and hiring in America. Russell Sage, New York

National Center for Education Statistics (2013) The Condition of Education 2013. U.S. Department of Education, Washington DC. Retrieved from National Center for Education Statistics: http://nces.ed.gov/FastFacts/display.asp?id=561

National Research Council (1998) Every child a scientist: achieving scientific literacy for all. National Academy Press, Washington DC

National Research Council (1999) How people learn: brain, mind, experience, school. National Academy Press, Washington DC

National Research Council (2000) Inquiry and the National Science Education Standards: a guide for teaching and learning. National Academy Press, Washington DC

National Research Council (2002) Learning and understanding: improving advanced study of mathematics and science in U.S. High Schools. National Academy Press, Washington, DC

Nugent S, Karnes F (2002) The advanced placement program and the international baccalaureate programme: a history and update. Gift Child Today 25(1):30–39

Parker W, Mosborg S, Bransford J, Vye N, Wilkerson J, Abbott R (2011) Rethinking advanced high school coursework: tackling the depth/breadth tension in the AP US Government and Politics course. J Curric Stud 43(4):533–559

Parker W, Lo J, Yeo AJ, Valencia SW, Nguyen D, Abbott RD, Vye NJ (2013) Beyond breadth-speed-test: toward deeper knowing and engagement in an advanced placement course. Am Educ Res J 50(6):1424–1459

Pierce R (2013) Student performance in a flipped class module. In: Society for information technology & teacher education international conference 2013. AACE, Chesapeake, pp 942–954

Rushton GT (2012) Improving high school chemistry teaching via the "Trickle Up" effect: a perspective on the new AP chemistry curriculum framework. J Chem Educ 89(6):692–693

Russo F (2000) Beyond advanced placement. Village Voice 45(15):90–91

Santoli SP (2002) Is there an advanced placement advantage? Am Second Educ 30(3):23–35

Schneider J (2011) Excellence for all. Vanderbilt University Press, Nashville

Scott T, Tolson H, Lee Y-H (2010) Assessment of advanced placement participation and university academic success in the first semester: controlling for selected high school academic abilities. J Coll Admiss 208:26–30

Smith D (2007) Why expand dual-credit programs? Commun Coll J Res Pract 31(5):371–387

Stieff M (2011) Improving representational competence using molecular simulations embedded in inquiry activities. J Res Sci Teach 48(10):1137–1158

Teo TW, Osborne M (2012) Using symbolic interactionism to analyze a specialized STEM high school teacher's experience in curriculum reform. Cult Sci Edu 7(3):541–567

The College Board (2012) Chemistry course description: effective fall 2012. College Board, New York

The College Board (2014a) AP biology lab manual resource center. Retrieved February 6, 2014, from AP Central: http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html

The College Board (2014b) AP central course descriptions. Retrieved February 5, 2014, from College Board: http://apcentral.collegeboard.com/apc/public/courses/descriptions/index.html

The College Board (2014c) AP Physics 1 and AP Physics 2. Retrieved February 6, 2014, from Advances in AP: http://advancesinap.collegeboard.org/math-and-science/physics

The College Board (2014d) How to earn credit for your scores. Retrieved February 5, 2014, from AP Students: https://apscore.collegeboard.org/creditandplacement/how-to-earn-credit-for-your-scores

The College Board (2014e) Put AP to work for you. Retrieved February 5, 2014, from The College Board: https://apstudent.collegeboard.org/exploreap/the-rewards

Tucker B (2012) The flipped classroom: online instruction at home frees class time for learning. Educ Next Winter 12(1):82–83

Tune JD, Sturek M, Basile DP (2013) Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology. Adv Physiol Educ 37(4):316–320

U.S. Bureau of Labor Statistics (2013) Employment projections, 19 December 2013. Retrieved February 5, 2014, from United States Department of Labor: http://www.bls.gov/emp/ep_chart_001.htm

Viadero D (2000) Study suggests fewer students receive ap credit. Educ Week 79(42):5

Wagner D, Laforge P, Cripps D (2013) Lecture material retention: a first trial report on flipped classroom strategies in electronic systems engineering at the University of Regina. Canadian Engineering Education Association, pp 1–5. Montreal, QC

Watt K, Huerta J, Alkan E (2011) Identifying predictors of college success through an examination of AVID graduates' college preparatory achievements. J Hisp High Educ 10(2):120–133

White J, Hopkins R III, Shockley D (2014) Gaining insights from a case study of high school student performance in dual-credit college chemistry courses. J Chem Educ 91:30–36

Willingham W, Morris M (1986) Four years later: a longitudinal study of advanced placement students in college. College Entrance Examination Board, Princeton

Young RD, Slate JR, Moore GW, Barnes W (2013) Dual credit enrollment: a multiyear study of gender and ethnic differences. Urban Stud Res 2013:269685. doi:10.1155/2013/269685

Zhai X, Leone M, Mieszala M, Hutson K, Rosenberg R, Carmichael D et al (2013) Promoting geoscience education through high school dual credit programs. 125th anniversary annual meeting & Expo. 45. The Geological Society of America, Denver, p 432