Implementing a Unified Science Course

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Abstract:
H.E.M. Jr/Sr High school has developed a course entitled “Unified Science” for its upperclassmen. The course integrates concepts from agriculture and science curricula and is co-taught by the school’s agriculture and science teachers. The course has taken a place-based approach in which students consider the economic and environmental impact of industries invested in their community and engage in progressive problem-solving tasks related to said industries. These tasks often include the engineering process and employ technology such as computer science, 3-D modeling and printing, prototype construction, and consultation with industry partners in the community. This proposed paper will focus on the experiences of students and teachers who have participated in this course over that last three years. The accounts will include the observed benefits of integrating the two content areas, some trial-proven elements for success in initiating such a course, and some insight into implementation strategies. The benefits to teaching and learning in a cooperative environment include: enriched relevance and rigor, enhanced connection among diverse content, inquiry-based instructional style, enriched teacher and learner creativity, amplified teacher enthusiasm and accountability, and diversity of teacher and student perspectives. Some essential elements for success to explore before unifying courses in your school and integrating progressive approaches to engineering concepts include the following. Schedules should provide a common planning time within the school day. Teacher buy-in, patience, creativity, and commitment to the development of the course is ideal. Funding & community resources will be crucial to the progress of the course. Teachers will need to commit to various professional development opportunities and garner the support of administration. Ultimately, for an elective course to sustain itself, it must maintain minimum levels of student enrollment which can be achieved through recruitment and retention efforts. Finally, a road map for implementation will be provided including course design models, suggested course content, instructional methods, and potential teaching recourses.

INTRODUCTION

The focus on secondary education in the 21st century has become centered around college and career readiness. Integrating content from more than one course will allow students to decompartmentalize their knowledge and allow them to apply core concepts to practical purposes (Santos et al. 2017). A small school in South-Central Wyoming is using this integrated model by providing a course entitled, "Unified Science" which melds content from the agricultural and science curriculums as well as the expertise of each of the content teachers. The success of this integrated approach has faced its share of challenges but has yielded vast benefits for students. This paper will describe some of those challenges and benefits as well as provide some resources for implementing a similar approach in any school.

Before diving into the world of cross-curricular teaching and learning, it is important to provide the context for this endeavor by presenting information on the school and community and the juxtaposition of the content in the current economic, educational and political climate. It will also be helpful to know the intended course outcomes and a calendar-based plan for implementation.

H.E.M Jr/Sr High School is located in Hanna Wyoming and serves students who reside in three communities each about 20 miles from the other. In total the three communities make up a population of about 1,000 people and the 7-12 grade school serves roughly 90 students each year. The school is very remote and there is very limited economic activity in the region; aside from energy production. Hanna was home to one of the largest coal mines in the region, Sinclair refining is down the road about 30 miles, and wind turbines sprinkle the landscape. Contrary to former student populations, many students reside within the city limits and have limited exposure to production agriculture. Still, agricultural production in co-existence with management of the region's natural resources is a key industry in the area.

At HEM Jr./Sr. High School the curriculum is somewhat limited as is the case in most small schools with inadequate resources and personnel. Students have access to core class and electives related to Career and Technical Education(CTE) and Fine Arts.

As the Unified Science course began to take shape, STEM, computer science, and CTE became a significant focus for secondary education in Wyoming as indicated by state-wide initiatives and legislative efforts. This climate encouraged the design and implementation of the Unified Science course.

Throughout the year, students enrolled in Unified Science explore vast and amorphous content which is altered and redesigned with each new group of students and shift in the local economic and political atmosphere. Typically, students spend the first quarter of the year gaining background knowledge on agriculture and becoming familiar with the engineering process and scientific method. Learning and interacting with the engineering process is foundational for the work to be done through the rest of the year in Unified Science. *A Framework for K-12 Science Education* outlines eight practice areas to employ through the engineering process including: identifying problems, developing and using models, investigating, analyzing data, using computational thinking, designing explanations and solutions, evidence-based argumentation, and gathering, evaluating, and expressing information (Dailey, 2017). The second quarter is spent interacting with local energy, agricultural, and natural resource industries. The theme of the second half of the course is experimenting and creating. Students use technology such as Arduino and Raspberry Pi computing systems, CAD and 3D Printing, and software development to explore and innovate solutions to issues discussed in the previous semester. A culminating project features data collection and/or an engineered product which is then presented to fellow students and community partners.

Success in implementing this course has been faced with numerous obstacles but persistence has generated tremendous benefits and ultimately sustainability of a practical and innovative integrated instructional model. This paper will chronicle these trials.

FINDINGS FROM OTHER STUDIES

Two components of a positive learning experience are rigor and relevance. Often, core classes are quite rigorous but leave students pondering the importance of the content. Meanwhile, elective courses often struggle to present complex content in a way that challenges students. Integrating content fills in these gaps throughout the curriculum (Scales, 2017). Additionally, allowing students to apply core concepts to practical learning allows them to make complex connections among diverse content (Scales, 2017). A material issue with secondary education today is that content and learning is compartmentalized by subject-matter and the norms of separation discourage cross-application of knowledge (Santos et al. 2017). Integrated instruction is a quest to overcome this phenomenon.

An integrated approach provides an easy path to modern student-centered teaching techniques. Inquiry-based learning is the natural mode of operation in an integrated classroom (Dailey, 2017). The practicality of the content leads students to explore the world around them and brings the place-based model to the forefront of instruction (Mohan, 2018).

The Unified Science course is designed to be planned and taught by two teachers of different content areas, which offers a unique set of benefits for all stakeholders. Teachers who are allowed to work together autonomously, produce limitless creativity which students are inspired to replicate (Hurd and Weilbacher, 2017). When teachers collaborate, students get the best from them. Their collaboration breeds enthusiasm and adds a sense of peer accountably; more dividends which are transferable to students. The diversity of perspectives postulated in larger groups of teachers and learners can be invaluable in a small school setting.

LESSONS LEARNED

The trials faced by the course designers and teachers involved in implementing Unified Science produced some hints for best practices or essential elements for success in execution.

It should be understood that a designed an implemented collaborative model requires diligence and significant time commitment. Success will depend on teachers' commitment to the course and administrators' commitment to providing as much common planning time during contract hours as possible. Common planning time is a valuable asset for fostering a collaborative environment and would be recommended in any initiative, but it is absolutely vital when asking teachers to deliver content collaboratively (Pratt et al. 2016). The inaugural year of offering Unified Science saw numerous Sunday afternoon "play-dates" involving two teachers struggling to get a robot to turn on. While the dedication to effective instruction via proper preparation is commendable, it is not fair to ask teachers to spend a large fraction of their personal time that is often required to prepare innovative lesson plans (Pratt et al. 2016).

Even so, an integrated course cannot be effective without teacher buy-in. Teachers must be passionate about the development of content and crave involvement in a way that thrusts them into the work of preparing content. Teachers must also emanate patience; the majority of trials employed in innovative teaching practices will end in failure. Still, persistence is paramount for many reasons. Persistence will allow the course to ultimately be fruitful and promote a culture of failing successfully in the classroom.

Curriculum which allows students to turn their dreams into creations requires immense funding and resources. While administration should commit to funding the course to the level needed for quality instruction, it often helps for teachers to aid in securing outside funding. The content relevance lends itself to procuring funding as there is infinite interest in supporting the development of the future workforce and its everchanging technical need. Incorporeal resources are also prized throughout the delivery of the course and can include community partnerships, career opportunities or an invested audience for students to share their accomplishments (Waltters & Diezmann, 2013).

Encouraging or even requiring teachers to participate in a healthy amount of professional development related to course development and delivery will pay off when implementing a unified course. There are numerous workshops and courses related to STEM, engineering and innovative course design, offered locally or nationally. A teacher must simply seek them out.

As implied throughout this section, perhaps the highest priority action item in commencing this innovative initiative is to acquire and maintain the support of school leaders. An autonomous balance is ideal but keeping administration involved in the excitement of the course can facilitate continued backing.

Ultimately, the most essential accomplishment of sustained prosperity for elective courses is a recruitment-focused mindset. The course will not continue without sustained enrollment. It is incumbent upon the teachers, school counselors, and administrators to emphasize the benefits of the course, garner enthusiasm, and promote achievements to future students. Endurance is dependent on a culture founded on a desire to participate in the course.

IMPLEMENTATION STRATEGEIS

Offering a Unified Science course begins with designing a syllabus and gaining course approval through the necessary local and state channels. Next, the teachers of the course need to develop a curriculum for the course which will incorporate content from each subject area. It is indeed best if the teachers design the course, as they will have more buy-in, excitement, and follow-through if they are involved in development of the curriculum.

Design Models

Collaborative, cross-curricular learning experiences can manifest in a variety of forms. Teachers may choose to team-teach a one-day lesson, a unit of study, or even an entire year or semester long course. No matter the length, logistics must be considered, such as:

Which teacher will have access to the gradebook?
In which teacher's classroom will class be held?
Will other classes be interrupted in order to complete the collaborative lesson?
If the learning experience is not a stand-alone class, who will do the grading and will outcomes impact student grades in multiple classes?

Personality considerations must be made among the collaborating teachers as well:

How will the work load be shared?
What norms need to be established for the team who will be planning and teaching together?
Who will be the disciplinarian?
Will teachers truly "co-teach" or will they split the planning/teaching duties?

In the experience of implementing the Unified Science course at HEM Jr/Sr High School, two teachers co-teach throughout the year-long integrated course. The teachers share the planning duties, teaching, and each have access to the gradebook for the class. The class generally met in a specific classroom but continually had access to the facilities offered in a science lab and an agriculture classroom and shop.

Suggested Course Content

Suggested course content is prefaced with the notion that integrated courses must introduce content which will be relevant, engaging, and somewhat fluid according to student interests, community and industry demands, as well as teacher expertise.

In the case of the Unified Science course which integrated agriculture and science content, the curriculum is divided into four quarters each featuring a themed unit of study.

In part due to the feasibility of conducting agricultural research outdoors during the fall months of the school year, the initial term is spent exploring agricultural issues and becoming aware of agricultural technology such as GPS and GIS technology. Students also learn about the soil and vegetative potential of the environment in their area. Finally, students are presented with the opportunity to make predictions, arguments, and innovations to anticipate consumption demands of the growing population in the face of diminishing natural resources.

The second quarter is spent exploring and innovating using technology. Students are trained in using the engineering process and applying it to coding exercises, programming Raspberry Pi and Arduino Operating Systems, and using web-based drafting software to design and print a 3D design project.

During the third quarter the class dives into the energy industry to explore environmental and economic impacts on energy and energy dependent industries. During this unit of study students explore energy production, distribution, and consumption from a variety of different perspectives. The location of HEM Jr/Sr High School offers unique opportunities to physically visit energy production facilities in a variety of fields. The unit culminates with a project-based lesson in which students explore the social aspect of energy production and strive to offer solutions for issues in energy production.

During the final quarter students complete a self-guided project which students seek to identify a problem, conduct primary and secondary research on that problem and potential solutions, and finally, develop a proposed solution for the problem in question. The "problem-based" project is intended to integrate knowledge and skills developed during the former units of study.

Instructional Methods and Potential Resources

Engineering Notebooks

During any research or exploratory learning experiences, students are asked to record any and all information into their "engineering notebooks." Typically, these notebooks are provided to students and are legitimate journals for capturing essential information which students may need to reference for problem solving purposes throughout the course. Great effort should be employed to express the allure of the engineering notebooks in the eyes of students.

It is advised to enforce limited, if any, guidelines in terms of how to capture or organize information in the notebooks. It is, however, recommended that a notebook check of sorts be conducted at various intervals to ensure the notebooks are fulfilling their purpose in the curriculum.

University of Wyoming Summer Program for Teachers

Much of the instructional materials and professional development required for the technology portion of the Unified Science course was gained through teacher participation in the Engineering Summer Program for Teachers offered through the University of Wyoming.

Additional online collaborative communities offer assistance and inspiration for implementing content-specific computer science initiatives including: hackster.io, Instructables, Raspberrypi.org, Arduino.cc, and Pinterest.

Code.org

There are many resources to consult when seeking to implement coding into any course. Determining the ideal resources is less important than a teacher's commitment to become intimately familiar with its methods and content. Code.org is one of the most popular resources and offers a turnkey website, vast curriculum, and extensive professional development.

TinkerCAD

The 3D printing unit in Unified Science asks students to identify a problem and then design a device to aid in solving that problem. TinkerCAD is a free web-based drafting application which also features interactive modules for training new users. During the 3D printing unit students are asked to complete the modules and then design their own project to be printed.

University of Wyoming Energy Education Initiative

The majority of the inspiration and content for the energy portion of the course has been developed and adapted through participation in the University of Wyoming's Energy Education Initiative. The initiative is rooted in the idea of integrating energy education into the context of core content.

Place Based

A large portion of the curriculum throughout the Unified Science course considers the environmental and economic impact of industries in the context of the local community and region. In some projects, exploration takes students beyond the local area to compare how industries are impacted in other regions. Students become exponentially more engaged and connected to their learning when they experience it in their daily lives, when they can relate to people in their lives who have vocational experience in the industry, and/or when they can see themselves playing a role in the future of the community.

Independent-Culminating Project

Students are given the opportunity during the entirety of the fourth quarter to complete a self-directed, culminating project. The project can relate to any topic of study the student identifies as an interest, but must apply many of the concepts and resources explored previously during the year. Additionally, the project must incorporate primary and secondary research efforts. The final product of the project includes a written report and presentation. Course designers strive to ensure that the results of the students' projects become published in some way within the school and community. This publication brings an added element of accountability and relevance for the students but also generates excitement for what is accomplished in Unified Science. The key to this project is finding the equivocal balance between creativity and requirement; call it: *structured autonomy.* Generally, the stumbling blocks for implementing this type of instructional model manifest in the beginning and the end of the project period. Given the freedom to explore anything of interest students struggle to find a launch point. One method for circumventing this unrestricted stagnation is the "Bad Idea Factory." High school teacher and author, Kevin Brookhouser, introduced this concept to his students in preparation for his "20time project" (an educational spin-off from Google's autonomy paradigm). Featured in a video found on youtube.com, Brookhouser asks students to develop a myriad of bad ideas, things that would be terrible to research. Students generate such atrocities as, "squirt lemon juice in my eye" and "find a way to get a man pregnant." From this discussion of terribly creative ideas, good ideas are born. For example, students discuss what people would think of you if you were a pregnant man, leading to a discussion on what people think of you if you are wheel-chair bound, leading to an observational study in which a student experienced being wheel-chair bound for three weeks in the school, leading to a project to complete a sidewalk outside of the school to make the facilities more accessible. This "bad idea factory" was implemented in the Unified Science course with great success and allowed students to begin their exploration with enthusiasm and uncontainable curiosity.

The key to helping students reach success during the ending point of their project is to apply the proper amount of structure and transparent expectations. Avoid guidelines on how the final product will manifest, but be specific as to how that manifestation will be evaluated.

CONCLUSION

Many themes emerged during the development of the Unified Science course at HEM Jr./Sr. high school. First, a good integrated course will promote student autonomy and innovation until it becomes the culture of the class. Additionally, developers and teachers should prepare for the magnitude of resources needed to execute a quality unified course. These resources include but are not limited to: funding, supplies, equipment and technology, space, time, quality curriculum, exceptional teachers, and eager students. Finally, an integrated approach very obviously requires exponentially more time, effort, resources and perseverance, but the return for that added input is invaluable.

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