Piloting a New Curriculum: A View from the Trenches

Abstract

Teachers who implement a new curriculum provide invaluable feedback to content development teams. Without this feedback, possible improvements to the material would not be known and consequently, not made. Teachers are in the trenches experiencing the various pains of implementing new educational programs. They see firsthand the impact on the students and, thus, recognize the positives, negatives, and potential improvements to the course design.

This paper presents the experience of high school teachers implementing new curricula – one based on the science of cyberspace called Cyber Science, and the other is a redesign of physics. Both courses were developed by Louisiana Tech University in collaboration with the Cyber Innovation Center (CIC), a 501c3 not-for-profit corporation. Physics and Cyber Science were originally piloted regionally in 2010 and 2011, respectively, and then, expanded to a larger region including schools in the states Louisiana, Texas, and Arkansas in 2011 and 2012, respectively.

Established through the CIC is the National Integrated Cyber Research Center (NICERC). NICERC's Cyber Science and Physics courses utilize many technologies and projects to drive to the fundamental content. Cyber Science, specifically, integrates various disciplines (engineering, computer science, and liberal arts) to convey the ideas of cyber. NICERC's Physics utilizes a microcontroller platform to convey physics concepts. With such unique curricula, teachers, undergo training through immersive, week-long professional development summer workshops to prepare for the upcoming year.

This paper provides unique perspectives in implementing new curricula through the narrative of high school teachers. Descriptions of the teachers' experiences include the professional development workshop, the implementation of the content, as well as student response to the material. Recording and reviewing such a *view from the trenches* is essential in future iterations of development and design for not only these courses but others as well.

Introduction

K-12 teachers are often charged with implementing new curricula in the classroom. Many times teachers are tasked with teaching entirely new courses[1, 2] and/or integrating new elements into their current classes[3, 4]. This can be a daunting task especially when K-12 teachers do not feel adequately prepared or supported in implementing the new material. Many times, the educational program requires new technologies or pedagogies that make them uncomfortable. Moreover, the new curriculum is typically developed by non-K-12 teachers who may not fully understand the interworkings of a K-12 classroom. However, instructors seem to overcome and teach the content to the best of their ability. Programs with quality professional development see success with their teachers[5]. Because these teachers are in the trenches experiencing every aspect of implementing new material, they can provide a unique perspective to the design and implementation process. Teachers are a valuable resource to curriculum developers.

The CIC in partnership with Louisiana Tech University has developed a range of new curricula for K-12. The educational programs from NICERC span three states. The demographic makeup of the schools implementing the curriculum is diverse including urban, rural, and suburban regions. The development model used to design these courses is based on the engineering design process[5, 6]. NICERC Subject Matter Experts, which included engineering and science faculty from Louisiana Tech University, designed the two courses with the fundamental content in mind. The design teams for both courses brainstormed projects they believed would drive the students to the fundamentals. The iterative nature of the process as well as the willingness to listen to “customer” (teacher) feedback has helped the designers to continually improve upon the content. Additionally, a focus has been placed on the partnership between K-12 teachers and university faculty. Using the model developed by Louisiana Tech University of establishing collaborative partnerships between K-12 teachers and the university, a comfort level with the new curricula is established early in the implementation process[7, 8]. Immersive professional development workshops help to familiarize the teachers with not only the content, but also the university faculty who developed the material [7, 8]; thus, building a rapport with the university faculty early in the process. Additionally, through the professional development workshops, teachers build a support network of cohorts.

The two curricula highlighted in this paper are specific to high school. The first is a look at the pilot and implementation of Cyber Science. Cyber Science is a new educational experience that integrates engineering, computer science, and liberal arts concepts into a sophomore/junior level elective class. Cyber Science utilizes the different disciplines to convey cyber related concepts. Partner teachers from the New Orleans Military and Maritime Academy, an inner-city charter high school, provide insight and valuable feedback into implementing this material.

Secondly, this paper looks at the implementation of a redesigned physics course. The redesign of the content provides a project-driven approach to physics. An experienced teacher from Benton High School, a suburban school, provides narrative on his experience in piloting and implementing the new Physics curriculum.

Cyber Science Curriculum

Cyber Science is based on the Cyber Discovery Model[9]. Cyber Discovery includes a week-long immersion into cyber for high school teachers and students. In addition to the week-long summer residential program, teachers attend two professional development workshops during the school year[9]. The professional development workshops help to build the comfort level of the teachers regarding the camp content as well as create a welcoming and inclusive environment with the university faculty team. Cyber Discovery uses the engineering, computer science, mathematics, and liberal arts disciplines to provide the context for cyber fundamentals[9, 10]. The camp strives to develop knowledgeable cyber citizens through its unique approach to teaching the concept of cyber [9, 10].

The Cyber Discovery developers received such encouraging feedback from the camp participants and school administrators that it was evident an expansion to the program was needed. Thus, the Cyber Discovery development team decided to create a year-long elective course called Cyber Science[6]. By expanding the program into the schools through the Cyber Science class, students who could not attend the camp could receive the benefits of the Cyber Discovery content. The team expanded the camp curriculum to include more in depth coverage of concepts as well as additional content. Cyber Science, like Cyber Discovery, uses a microcontroller to convey concepts and provide a level of engagement for the students while integrating the engineering, computer science, and liberal arts disciplines. The disciplines are completely interwoven. In a given week, students will learn various cyber themed concepts[6]. For instance, students learn about artificial intelligence by programming the microcontroller to read input from a sensor to navigate a given route. Then they discuss artificial intelligence through computer science using heuristics. Additionally, the students debate the ethics associated with artificial intelligence and when legal rights should apply to artificial beings.

Teachers attend a week-long, immersive professional development workshop for Cyber Science the summer prior to teaching the course[6]. Following the professional development workshop teachers gain access to all curriculum materials including lesson plans, master notes, and supplemental documents which are found on NICERC's website. Communication is maintained throughout the school year via the website allowing for any questions, concerns, or issues a teacher may experience when teaching the material.

Narrative #1 – High School Teachers' Perspective on Cyber Science

The New Orleans Military and Maritime Academy (NOMMA) is a Type 2 charter school located in Federal City in Algiers, Louisiana, which is part of Orleans Parish. As a Type 2 charter school, NOMMA accepts students from not only Orleans Parish but the many surrounding parishes as well. As such, the student body of the school is very diverse with a wide range of skill levels and interests.

One of the crown jewels of NOMMA and one of the major selling points to potential students is Cyber Science. The idea of taking classes that involves the building and programming of robots is fascinating to both current and potential students of NOMMA. Cyber Science is highlighted and placed in the forefront of open houses and student recruitment ventures.

The Cyber Science curriculum at NOMMA is led by Dr. Charles Gardner, who develops the "hard science" and programming portions, and Mr. Anthony Taffaro, who is responsible for the liberal arts and general computer science components. At NOMMA, Cyber Science is a course that is offered over a two year period – Cyber Science I and Cyber Science II. Cyber Science I focuses on an introduction to electricity and circuitry; flow charting; basic programming; Boe-

Bot® building; programming and testing; general computer science such as networking, passwords, and data security and infrastructure; and liberal arts. Cyber Science II consists of advanced Boe-Bot® programming and projects, general computer science topics, and liberal arts.

The curriculum provided by Louisiana Tech University and NICERC is very comprehensive and serves to aid in development. At NOMMA, much of the material provided by NICERC is used in its entirety for the creation of daily lessons. The material serves as a guide for how the instructors at NOMMA are able to enhance and expand the content in order to serve all students who wish to take part in this unique learning experience.

The administration at NOMMA is extremely supportive of the Cyber Science curriculum and spotlights the class as one of the components that sets NOMMA apart from other high schools of its type. Both the principal and commandant of the school are always interested in what we are doing in the classroom and look for ways to help the Cyber Science instructors. In fact, the administration is already making plans to send Gardner and Taffaro, along with a contingent of NOMMA cadets, to the Cyber Discovery camp at the beginning of summer 2013. Additionally, the plans for the new NOMMA campus include two classrooms set aside and designed specifically as Cyber Science classrooms/labs. The program has even caught the eye and interest of the board of directors, which is fully supportive of and excited about the potential of the program and its effects for NOMMA's cadets.

The professional development offered by NICERC through Louisiana Tech University is outstanding. The individual presenters are extremely knowledgeable and engaging, which instills confidence in the instructors so that they can indeed take what they have learned back to their classrooms and be prepared to share their learning with the students. The online materials provided make it very easy to implement the course and the generous gift of equipment by NICERC only serves to make implementing the curriculum even easier at little to no cost for the school. Upon leaving the summer professional development workshop, a teacher feels empowered to return to his or her classroom knowing that he or she will be successful.

Because NOMMA spreads the Cyber Science course over two years for its students, the instructors have found it both challenging and fulfilling to enhance the content. This provides the instructors with the unique opportunity to take the provided material and make it accessible to students of wide and varying backgrounds. Gardner and Taffaro use a co-teaching approach to design and implement the curriculum by relying on the knowledge and abilities of each other to create a content that serves the needs of the cadets. This teamwork allows each teacher to use his or her own strengths as well as learn from the expertise of the other. This unique relationship makes the curriculum stronger for the cadets. Through the tandem creation of lessons, each class is guaranteed to receive the same information thus insuring that the content is consistent for all cadets. The cadets are also well served since they can feel comfortable going to either instructor for assistance knowing that each is well versed in the material.

At the beginning of the school year, it was determined that the Cyber Science I and II classes would be scheduled at the same time. This is advantageous because Gardner and Taffaro can bring their classes together as a group allowing the cadets to work together on large projects as well as giving the cadets the opportunity to work in groups that vary in skill level and knowledge. The foresight in the scheduling by the administration has also allowed for the students in Cyber Science II to work alongside their counterparts in Cyber Science I and to act as mentors and "teachers" for the younger cadets. This allows the more advanced cadets to create a rapport with the younger cadets and prove their own understanding of the material. The younger cadets can also view the advanced projects being accomplished by the Cyber Science II class which excites them about what they will experience next year.

Because the cadets of NOMMA come from such diverse backgrounds and educational abilities, it is sometimes difficult to implement some areas of the curriculum because it requires a higher level of understanding in mathematics and computer literacy or science, electricity and circuitry, and civics. Therefore, the cadets need to be eased into Cyber Science by the introduction of some of the aforementioned material. It is the opinion of the instructors that the content, as it sits, is more grade-level appropriate for junior/senior level students who have a stronger background; however, much can be modified for freshman/sophomore level students. For example, some of the concepts on the liberal arts side are difficult for an average ninth or tenth grader to comprehend. There has been some resistance to these topics from the students. As a result, it was necessary to adapt the liberal arts portion to a more appropriate grade level. In this semester, discussions of Internet usage and ethics, the rights and responsibilities of a cyber-citizen and the political agendas of the Republican and Democratic presidential candidates have taken center stage along with a look at current events. The cadets have found these topics engaging and have participated with excitement in the projects and discussions that center around the topics. The cadets enjoy discussing and learning about the various topics in computer science, especially the discussions on networking. Using the networking project provided by NICERC, the cadets became the nodes and lines of communication while others acted as the "Man in the Middle" or the "Denial of Service." This enhanced their understanding of sending messages through cyberspace and threats that exist.

Cyber Science is one course which has been accepted readily and enthusiastically by both the Cyber Science instructors and the NOMMA administration. This excitement is reflected in the cadets' interest and desire to engage and learn more in their Cyber Science classes. Ultimately, it is the intention of instructors and administration to make Cyber Science a central feature around which the culture of NOMMA is built – "Developing Tomorrow's Leaders Today."

Physics Curriculum

At Louisiana Tech University, the freshman first-year experience called Living *with* the Lab continually yields success through the project-driven approach in teaching fundamental engineering concepts. Because the project-driven approach demonstrated success on the college level, professors at Louisiana Tech University decided to draw from Living *with* the Lab to create a project-driven physics for high school.

The Physics course utilizes a microcontroller as the platform for instruction. Because the platform is electronic based, the course designers decided to begin the curriculum with Electricity & Magnetism[1]. Most physics classes begin with Work & Mechanics. However, beginning with Electricity & Magnetism helps to develop a better understanding of the microcontroller platform, which acts as the hook to engage students in the curriculum. Following the Electricity & Magnetism unit, the content is designed to transition into the Work & Mechanics unit. This forms a seamless transition because students move from discussing electrical power to mechanical power which flows well into the concept of efficiency[1]. Students use the microcontroller to develop for themselves an intuition for these concepts. Following the Work & Mechanics unit is the Light & Optics unit, Waves & Sounds, and then Thermal Fluids[1]. Content designers developed the curriculum to follow this progression; however, teachers have the freedom to adjust the schedule of the content to best suit their class needs.

Much like Cyber Science, teachers attend a week-long immersion into the curriculum in the summer prior to teaching the course[6]. Following the professional development workshop, teachers gain access to all materials including lesson plans, master notes, and supplemental documents which are found on the NICERC website. Communication is maintained throughout the school year via the website allowing for any questions, concerns, or issues teacher may experience when teaching the material.

Narrative #2 – High School Teacher's Perspective on Physics

When reflecting on piloting NICERC's Physics, two essential components were the integrated activities and projects. The curriculum uses the Boe-Bot® microcontroller as the platform for education. The Boe-Bot® is a simple, versatile, and resilient platform. The documentation developed for the course and provided by Parallax® has been more than adequate to conduct the experiments and projects. NICERC provided a full technology package, which was also critical to success.

That being said, integrating the large number of activities, which include several lengthy projects, made it very difficult to complete the content in a single semester on the block system. Pacing can be a challenge with any new curriculum, particularly with the number and range of activities offered by this course. We have spent some time tailoring the material to a block system and working to balance lab time with traditional problem solving sessions. The 90 minute blocks worked well for some of the more lengthy activities but did not leave enough time to cover the core physics curriculum. We worked around this problem by working with the state Department of Education to approve a two semester version of the course. In the first semester, we teach Electricity & Magnetism, Waves & Sound, and Light & Optics. In the second semester, we cover Work & Energy, Mechanics, Fluids, and Heat. This solution has worked well in some of our partner schools and affords us the time to really get into the hands-on activities.

The upfront training provided by NICERC and Louisiana Tech University has been critical in giving teachers the orientation, skills, and confidence they need to implement the curriculum. These workshops also provided an outstanding venue for collaborative discussion and feedback, resulting in content and implementation improvements. We also developed working relationships with the Louisiana Tech University faculty and peers at other partner schools, which continually helped to answer questions and share information.

In terms of student perception of the course, our students have really enjoyed and embraced the curriculum. Most students really enjoy the lab activities, which also, and most importantly, provide the basis for much of the theory that we cover. We see a range of interests and aptitudes in NICERC's Physics. Students tend to fall into the following categories:

(A) Some are already interested in technology and engineering in which case, the circuits, robotics, and programming are a very real interest for them. They jump into the projects and often go further playing with sensors and extending programs to perform more operations. Many of these students also do well in the relevant theory and problem solving activities. However, some tend to see the core physics as less appealing, preferring to stay in the lab, and may not apply themselves in working complex, multistep problems.
(B) Some are interested in pure science and/or are planning to pursue other scientific fields (e.g., medicine). These students sometimes have little interest in the bots and programming but may do well in learning theory and taking tests.

Unfortunately, most students have never done any programming or worked with spreadsheets. Some students struggle with programming beyond simple commands. Programs of any length, which required use of several subroutines and "IF…THEN" logic, were a struggle for many of the students. We have not emphasized programming in the course; we see it as an enabling technology which allows us to explore physics concepts. They also have not worked extensively with multistep "word problems." They have a natural aversion to these types of problems, which is most likely due to the sometimes confusing and almost always "non-real world problems" they see in textbooks and on standardized tests. Many have never learned to neatly and methodically write down given information, draw neat diagrams, and work through a problem solving process. In order to push students even further with the physics fundamentals, we adopted a physics textbook supporting Advanced Placement that provided additional reading and problem sets.

To conclude, high schools teachers in the state are heavily loaded with duties ranging from implementing new common core curricula and performance evaluation components to extracurricular activities. Programs like this physics course need to be produced as turn-key products with full funding and support. In order to really integrate activity/project driven learning of this caliber into high school STEM curricula, it is essential that we target core curriculum courses. With students needing a number of required courses to graduate and to receive in-state tuition from TOPS (Taylor Opportunity Program for Students) coupled with the demands placed on student athletes and band members, most students have little to no room in their 4-year academic plans for additional electives. We are also more likely to engage and motivate students to pursue STEM degree paths when we contact them in core courses. Many students who were enrolled in this course experienced a positive change in regards to their interest and aptitude of STEM and have gone on to pursue STEM paths in post-secondary education.

Conclusion

Through this *view from the trenches*, designers of curriculum are able to evaluate the content created. The teachers' perspectives help the developers to assess how the material is presented and if there are any improvements that can be made. Specifically, the feedback from Cyber Science teachers, much like what is found in the narrative of this paper, helped the content developers to determine the appropriate grade level for the material. Initially, Cyber Science was targeted as an elective for 9th or 10th graders. Through feedback from teachers, it was determined that the material is better suited for students who are enrolled in or who have taken Algebra II (typically 10th, 11th, and 12th grade).

Similarly for Physics, teachers provided feedback that there were so many lessons in the curriculum that they could not complete all the content in one school year. Thus, a framework for a two part course was developed. For those schools who could not teach Physics in two parts, a skeleton version of the content outlining the essential and less essential components is under development. This will help teachers know which lessons are most crucial. These and other lessons learned from the views of the teachers will be further described during the presentation of this paper.

In addition to teacher feedback helping the developers redesign the content, the information from the teachers can help researchers formulate questions that will evaluate the course efficiency. Numerous questions can be drawn from the teacher feedback that would provide meaningful research topics, specifically, questions on grade-level appropriateness, i.e., understanding at which grade level the content makes the most impact. Also, questions related to how students perceive the projects can be addressed. Are the projects truly driving to the fundamentals like the designers planned? For example, Mr. Nelson, who provided feedback on the physics course mentioned how programming was not a major component of the class, but was used supplemental to the lessons. One might ask how does the programming component enhance or hinder the experience of the students. Many research questions can be formed through compilation of the teacher perspectives. The first step, however, is gathering that feedback.

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