

STEM EDUCATION IN HIGH SCHOOLS: INFORMATION TECHNOLOGY AND
WIRELESS NETWORKS

by

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Abstract

With the COVID-19 pandemic that has moved so many of our lives virtual, the importance of IT and wireless networks has never been clearer. As virtual living become a bigger component of day-to-day life, so to does the importance of mobility and flexibility, benefits which wireless networks bring. Wireless networks are becoming the new norm, often replacing the wired networks of yesteryear. However, STEM and networking education, particularly in areas with fewer resources, have been slow to catch up, with a much heavier emphasis on wired networks and only a minor inclusion of wireless in most cases. While understanding wired networks is crucial to understanding basic networking functions, and wired networks is still widely used, it is important to educate the incoming IT workers of newer technologies. Possibly more important is gathering their interest in the field; with high school students being so enveloped in the wireless world, providing education and information that focuses on wireless and the computers in their pockets may attract some of the newest, brightest minds to the field, be it in the workforce or the field of study. This report details the project undertaken to do just this, and explores the process used to create lessons and hands-on activities to educate and entice. Along the way, it will also explore successes, difficulties, lessons, learned, and improvements and next steps for the project.

Keywords: STEM, education, IT, wireless

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Introduction

The importance of wireless networks has never been greater than it is now. According to market research conducted by PR Newswire the revenue in the global wireless market is expected to expand from \$1,431.3 billion in 2019 to \$5,519.4 billion by 2024 (Research and Markets, 2020). With the recent pandemic, the position of wireless networks and wireless internet access as an important staple in homes and the workplace has never been more proven and solidified. As more and more wireless devices become available, wireless networks are becoming more prevalent and, in some cases, even preferred. With this knowledge, it is vital that our future workforce understands wireless networks, how they work, and why they are needed. This project, led by Alexander Hodges (Honors College student) and partnering with other members of the ICTN program (Cayce House, Elisabeth Heath, Jonathan Harrison, Jamie Hancock), took this task on by creating lessons and activities to educate and encourage high school students to explore the IT field. The following report details the project process, beginning with a description before detailing the background, scope, duration, and creation of the project. Later, success, difficulties, and lessons learned from the project are discussed before exploring some improvements that could be made to the project and next steps, ending with an explanation of the presentation of these projects and a conclusion.

Project Description

This project created several lessons exploring the concept of wireless networks and protocols targeted towards high schoolers. The intended outcome of this project is to spark interest in the audience to explore IT fields in their career or further education; to accomplish this goal, we will create interactive, engaging lessons full of audience-appropriate content to initiate curiosity in the field. Along the way, the project's lessons will also educate the students and

provide STEM teacher in the high school with well-planned and structured lessons with which to teach the material or base other lessons off of, as well as bring attention to ECU and the area of study. The project began on August 10 and was broken into a few sections spanning roughly 8 months (two semesters); creation of the presentation and lessons was completed by the end of the first semester, after which implementation, trial, and revision took place. This project was based entirely online; while this was not the original plan, adjustments had to be made to accommodate to COVID precautions. The project focused on local areas in eastern North Carolina based on previous high school stem class experiences, as well as communication with previous high school STEM teachers. The project required no specific funds.

Project Background

This project directly addresses the lack of information high school students have about the variety of paths the IT field can offer while also encouraging enrollment in IT programs or career exploration. The education received at East Carolina University as well as work and personal experiences created a great knowledge base of both IT and the its work environment and provided the inspiration for the project. This project can provide a great benefit to all involved stakeholder, including the audience of students, schools, teachers, the workforce, and the university. The project will encourage exploration of the field in students, which will provide a larger workforce or larger enrollment in IT degree programs, which directly benefits the workforce and East Carolina University. It benefits the teachers by establishing straightforward, simple guidelines on how to teach these topics and provides a general structure they may follow in teaching other, similar topics. The resources needed to teach these lessons are all provided.

Project Scope

Having a well-defined project scope, and properly managing the project to stay within the defined scope, is crucial to the efficiency and effectiveness of the project. The project scope is the defined and established set of goals, deliverables, boundaries, tasks, and other factors of the project that influence how the project is completed (Heather, 2018). Managing the scope and ensuring that it is not too wide and does not fluctuate too much involves three primary processes: planning, where the project and tasks are planned and outlined; controlling, which limits scope creep or change; and closing, where the effectiveness of a given project is measured and improvements are noted. In an iterative project like this one, the process will repeat after the closing stage. Managing project scope helps the project avoid common scope issues, including constantly changing requirements, mid-project pivots, final outcomes that do not live up to expectations, and falling behind schedule (Team Clarizen, 2020).

This project's scope was defined by first establishing the project goals. Project goals are the "destination" of the project and define what the project hopes to accomplish. Three primary goals were established for this project:

1. Encourage students to explore and consider the IT industry
2. Educate students on various IT topics
3. Develop presentation and project management/creation skills

The first two of these three goals are targeted towards the audience; they state what the audience should get from the project. The final goal is targeted towards the creators, and states what the creators should learn during the completion of the project. Next, the main deliverables for the

project were established. These include the specific products, processes, or services that the project provides. The established main deliverables include:

1. Lessons in the module covering various IT topics (specifically, wireless networking and related topics)
2. Engaging content (Hands-On Activities) to keep students engaged, interested, and intrigued
3. Presentation of the material created (available for use as well as feedback and criticism)

These deliverables keep the project in scope, and allow the creators to track the project's progress as the deliverables are finished. Finally, it was imperative that the project had boundaries in place to explicitly define what it would and would not cover. The established boundaries keep the scope of this project targeted and direct. The project, for reasons discussed later, revolved solely around wireless networking concepts. Therefore, most general networking, security, or other IT concepts were not discussed. Desktops were also not commonly used in examples or activities, as those generally use wired Ethernet connections. Due to our target audience and the limited knowledge and time they have, the project remained somewhat surface level on a wide array of topics; too much detail will create confusion and disinterest, while not enough will likely bore the audience. The organization type that the project addresses was kept general, meaning corporate and home networks were not targeted specifically in most cases.

Project Duration

This project covered two semesters of work total, including research, creation, presentation, revision, and so on. The project had three initial phases, though the phases may not

necessarily go in order (for example, after completing phase two, it may be necessary to go back to phase one to pivot the project plan). The three phases for the project are as follows:

1. Phase 1: Project planning and research
2. Phase 2: Project content creation, assessment, and reiteration
3. Phase 3: Presentation, execution, feedback, and revision

These phases repeated several times throughout the project, and will likely continue to repeat as the project continues to evolve. Within these three phases, several project milestones were attached. These milestones also carried an associated timeframe for completion to keep the project on track. Five major milestones were established; these include:

1. Milestone 1: Project charter and general information established (first two weeks of the first semester)
2. Milestone 2: Project outlined and planned, authorized to proceed; research begins (mid-point in the first semester; research should ideally be complete by the end of the first semester, though occasional research beyond this is expected)
3. Milestone 3: Lesson slides complete and ready for assessment and revision (end of the first semester)
4. Milestone 4: Remaining deliverables complete and ready for assessment and revision; assessment and revision of all documents ongoing (mid-point of the second semester; revisions and assessments are ongoing)

5. Milestone 5: Presentation of the project, receive feedback, revise (end of the second semester; the revision and feedback processes are constant)

These milestones allowed the project to stay on track or, if it got off schedule, allowed specific actions to be taken that ensured it would get back on schedule.

Project Process & Creation

The project process began with the selection and planning phase. First, before any detailed planning could be done, a topic had to be selected. The topic this project focused on was wireless networks and protocols. This topic was chosen for a number of reasons, one of which is the comfort level and knowledge base available to pull from. The project creator and partners had knowledge and work experience in the field that they were eager to share, but also wanted to develop a further understanding of the topic. Additionally, through personal experiences, it was identified that networking education, especially in high schools that cannot always afford the best wireless resources, focused heavily on wired networks. While this education is vastly important to understanding networking as a whole and important in the workforce, wireless is becoming the new norm. Therefore, it is important that schools without the resources to effectively teach about wireless networks be provided with the resources to do so; in this case, those resources include lessons and hands-on activities that utilize free, widely available software. Finally, this topic was especially pertinent to high school students because of their familiarity with wireless networks and mobile devices; learning how these tools they use every day, tools which have become an integral part of their lives, could definitely spark interest in IT or related STEM fields.

After the overall module topic was selected, several lesson topics were selected as well. These topics included wireless networking, wireless security, mobile devices, mobile computing and applications, and wearable devices. These lessons were designed to cover key topics in the field of wireless networking, and are important to a variety of career paths students may take. The lessons were designed to address appropriate North Carolina education standards, and built on the knowledge established in the previous lesson. This allows for increased depth of information as well as increased topic coverage.

After the lesson topics were selected, planning of the lessons could begin. Keeping the previous lessons in mind, as well as the goals for the project and the NC education standards being addressed, a lesson structure was planned and established. This lesson structure allowed for consistency and efficient workflow in creating the lessons. It was established that the module would contain five lessons, as previously established. Each lesson would consist of a slide deck with a script, as well as instructor notes. In addition, each lesson had many review questions built in, both between sections and as a final review; each lesson was also recorded to allow for a self-paced, self-taught option which would work particularly well for virtual education where the instructor may not lecture every class period. Each lesson had to be mindful of the time students have in a class as well; since class time is limited, the lesson length had to be somewhat limited, a factor which further limited the depth provided in the lessons. Each lesson is accompanied by three hands-on activities to reinforce concepts taught in the lessons and encourage critical thinking and hands-on experience. Each activity lasts no longer than twenty minutes, and the activities employ various teaching methods to ensure maximum learning capabilities for all students. These various teaching methods include research, audio and visual, and hands-on. Each hands-on activity was recorded, much like the lessons, to allow for a better virtual teaching

environment and to assist students in the event they are stuck. Like the lessons, the activities also have review questions built in to test the student's knowledge and ensure they understand the material provided.

The next few sections of this paper will provide a detailed example of what content is included in a given lesson. This example will use lesson one, which can be found in the links provided in Appendix A. Each lesson begins with a listing of the NC educational standards it addresses. Lesson one, which focuses on wireless networks and protocols, focuses on the following NC education standards:

- ISTE NC.DLS: EL.1a. Students articulate and set personal learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process itself to improve learning outcomes.
- ISTE NC.DLS: EL. 1c. Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
- ISTE NC.DLS: KC.3a Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.
- NC CET I: 2.05 Compare and contrast various Wi-Fi networking standards and encryption types.
- NC CET I: 2.07 Compare and contrast Internet connection types, network types, and their features.
- NC CET 1: 2.09 Use appropriate networking tools.

Following this is a brief overview of the lesson, including its structure, objectives, key takeaways, and estimated length of the lesson. Lesson one consists of several topics which explore the basics of wireless networks. It features several sections as well as assessments at the end of each section and the lesson as a whole to reinforce learning. This lesson is focused on educating high school students, particularly upperclassmen, on the basics wireless networks and encouraging further exploration of the field. The topics and key takeaways include:

- What are wireless networks, how are they used, and what are their benefits?
- How do they differ from wired networks?
- What are common wireless network types?
- What are common wireless protocols and standards?

This information could be applied to the workforce and places of business, to further education in the IT field, and even in the home and personal life as wireless networks grow in size, prevalence, and available devices. The students should plan to dedicate between fifty-five minutes to an hour for this lesson: forty minutes for guided instruction as well as fifteen minutes or more for instructor additions, comments, assignments, or otherwise.

The next portion of the lesson addresses the key learning objectives that students should achieve from the lesson. For lesson one, students should be able to achieve the following objectives:

- Define a wireless network and its benefits

- Compare and contrast a wireless and wired network to identify advantages and disadvantages of each, and determine when each should be used
- Identify types of wireless networks, their benefits/differences and when they are used
- Choose a model that is most appropriate for a given, straightforward scenario
- Match common wireless protocols/standards with their uses

The next portion of the lesson addresses any prior information, if any, that the students may be expected to know. For lesson one, the only prior knowledge required is a basic understanding of networks and hardware, typically covered in wired network education. The following section addresses required student resources; for lesson one and most of the other lessons, the only resource the students need to complete the lesson is Internet access. However, some of the hands-on activities require specific programs.

The final portion of the lesson content is the slides, scripts, and instructor notes. The slides are structured in the same way across lessons; there are several sections, each dedicated to a topic, followed by a review. At the beginning of each lesson is the title and introduction, as well as an overview of the learning objectives, and each lesson has a summary and final review at the end. The sections covered in lesson one are:

- What is a Wireless Network?
 - History of Wireless
 - Uses of Wireless Networks
 - Hardware Used

- How They Work
 - How Do I Connect?
 - Review
- Wireless vs. Wired Networks
 - Advantages of Wireless/Wired
 - Disadvantages of Wireless/Wired
 - Review
- Common Wireless Network Types & Security Protocols/Encryptions
 - Common Wireless Network Types
 - Common Wireless Network Security & Encryption Types
 - Review
- Common Wireless Network Protocols
 - Common Wireless Network Protocols for WLANs, WWANs, and WMANs
 - Common IEEE Protocols/Standards
 - Review
- Summary
- Final Review

Each slide also has a script that accompanies it; this is the same script that was read out during the video, and could also be used by the instructor. Each lesson also has instructor notes with it, which provide a brief overview of the lesson, its importance, the learning objectives, and provides various discussion topics and questions for the students, as well as additional options for projects and activities and a list of additional resources for more information. This is concluded with the Key Terms needed to understand some of the technical lingo in the presentation.

The hands-on activities which accompany the lessons are designed to further solidify information provided in the lessons as well as provide some critical thinking, hands-on, practical experience that is applicable outside of the classroom. Each lesson has three accompanying hands-on activities, and the activity structure is shared amongst the lessons, though the activities themselves are diverse. Again, the lesson one hands-on activities will be used as the example. Each hands-on activity begins with a brief background about the activity, its importance, and information about the tools being used, if any. This background information is followed by setup instructions before diving into the activity itself. Hands-on activity one for lesson one is a critical thinking, situation analysis activity. It tasks the students to read through the needs of three clients and identify, based on context clues, which network type best suits the stated needs and why. This is a critical skill in the workforce; being able to identify and prioritize a customer's needs will lead to better solutions. Hands-on activity two is a more hands-on activity and uses Cisco's Packet Tracer software, a network simulation software, to emulate a wireless network. In this activity, students are tasked with following the instructions outlined to learn and understand how to set up a SOHO (small-office, home-office) wireless network consisting of a wireless router, access point, and several devices. The third hands-on activity for the lesson tasks students with

studying the path of a packet to better understand how wireless networks communicate. It then guides student through identifying where an error exists in the network and how to fix it. This is a basic introduction to troubleshooting a network, wireless or otherwise, a skill which is essential in the field. Each hands-on activity is followed by review questions that reinforce the student's learning.

Each of these products were recorded in videos to assist in the virtual learning process, as well as the documents themselves being provided to anybody free of charge.

Successes & Difficulties

Throughout the course of completing this project, there have been numerous successes and difficulties. The project planning process was a huge success; the quick but meticulous planning prior to beginning the project ensured that the project could continue quickly and relatively smoothly, and allowed for better time and project management. Another success is that the project was able to accomplish its goals. While it is not perfect, it is definitely an improvement and could surely be a value-adding product to many local schools, students, and even the university. The degree of success the project experienced in covering so many topics to an appropriate depth was high, and would definitely do a considerable amount to attract and educate the target audience. Additionally, the project was successful in its flexibility; while having the plan, schedule, outline, and structure was instrumental to the success of this project, equally instrumental was the ability of the project to remain somewhat flexible when new scenarios were presented. When the project first began, it was a totally different idea; originally, the project was supposed to assist local organizations upgrade their IT infrastructure or otherwise complete IT projects. Then, as the pandemic hit, the project had to be shifted to something which could be done virtually, so it took the shape of creating lessons for local high schools. As the

pandemic persisted beyond the timeframe originally thought, the project pivoted again from virtual creation plus live presentation to strictly virtual. Without allowing the project to remain somewhat flexible, and without the quick but detailed planning, the project easily could have floundered or completely fizzled out. The project is also very applicable to the local community, especially after seeing the virtual world the pandemic has forced upon society. As such, the importance of IT, including wireless, has never been more understood. These lessons are applicable in not only educating the next generation of the IT workforce, but in attracting them to the field. The lessons and videos are also well-developed so others, not just high school students, could most definitely benefit and learn from them as well. This project is, overall, a resounding success in its ability to be beneficial to all stakeholders.

All these successes do not discount the difficulties faced along the way. First and foremost, no plan can cover every scenario that may be encountered. The rapid shift forced quick project adjustment and a loss of direction for a time, though this was rectified. Additionally, with the world being virtual now, personal and work lives have never been more combined. Due to this fact, balancing rapidly changing commitments and priorities proved to be quite difficult for several reasons. When the two worlds collide, it can be difficult to separate the two and dedicate time for both that makes sense. Often, family matters come up that take priority over project completion or that may influence the priority of the project. Coping with constantly changing schedules, commitments, and priorities put the project under immense stress. Changes in project times often had to be made to accommodate some other responsibility. This difficulty, though never gone, was overcome by a combination of strict planning and scheduling but also remaining flexible. Planning and scheduling were important to identify when project aspects needed to be done and how long they may take, but flexibility was required in establishing times to work on

said project. Another difficulty this project faced is changing expectations and expectations which, at times, were unclear. As the project went through various iterations, it sometimes became difficult to define exactly what the new expectations were. Over time, as the project progressed through planning into completion, the expectations became clearer. There was always an idea, of the expectations, but the quick pivoting of the project early on left the project playing catch-up for a time. Limited interaction and recorded lessons limited the amount of feedback, response, and questions that a live audience gets, as the project relies on people clicking on, viewing, and reacting to the recordings. This made it more difficult to get feedback from which the project could improve, a process that is still ongoing. Finally, this project was an all-new experience; virtual presentations and projects are not typically common. However, using knowledge from other experiences, the project was managed and completed successfully, and many lessons were learned along the way.

Lessons Learned

During the completion of this project, many lessons were learned or reinforced. The importance of communication was one such lesson. With the project being moved to a virtual setting, it was imperative that partners in the project, including the mentor and individuals who provided feedback, stayed in communication as well as possible, especially to ensure that the project stayed on track and was addressing the needs of those involved. The importance of planning was also reinforced; without proper planning, the project would not have had as much consistent, quality content as it does, and the project would not have been able to be completed the way it was, both in terms of quality and overall speed. The importance of an established workflow accompanies this. The workflow established provided logical, clear steps on where to start, how to progress, and so on, allowing for more efficient and effective work. The importance

of flexibility was already discussed; though planning is of utmost importance, so too is remaining flexible enough to absorb whatever circumstances life may throw at the project and keep it alive. The importance of self and constructive criticism is a lesson that must not be forgotten. Without self-criticism, the project would not have been held to as high of a standard and, therefore, could have suffered in quality. Additionally, constructive criticism allows fresh minds and eyes to look at the project, which may, or may not be educated on the topic, and identify areas of improvement which make for a better product overall. Finally, the importance of accurately and fully defining and understanding problems was reinforced. In order to correctly address an issue, the problem must be fully and correctly defined. This was crucial in determining the goal and direction for our project as well as dealing with pandemic circumstances.

Future Improvements & Next Steps

In the future, there are a number of improvements that will be made to the project. These are commonly improvement which were planned and simply not completed yet or improvements which have been suggested or identified that have not been incorporated yet. For the documents and videos, one thing that can constantly be improving is the editing of the products. This will improve the visual appeal and professionalism of the products, and could work to attract a larger audience. Additionally, considerable improvements could be made on the detail and depth of certain content. When comparing one lesson to another, it is clear that some lessons have a considerably larger amount of detail than others, be in content on the slide, in the script, or in explanations of activities or review questions. This improvement partners with the next two, improving quality and consistency and establishing clearer requirements and expectations, to create a higher quality, more consistent product. Finally, a minor improvement that could be

made is document management. Often, the documents for this project were stored in a variety of locations, making it difficult to organize and keep track of.

In the module and lesson planning, there are a number of improvements to be made. First, a more consistent schedule would allow the workflow to be more efficient and effective. The schedule had to do a significant amount of shifting to accommodate other responsibilities, but finding a way to keep it somewhat consistent would likely increase efficiency by allowing for better prioritization. Another improvement, which has already been discussed, is establishing clearer and measurable quality standards and expectations. The expected quality for the project was, overall, clear, but it was ultimately unmeasurable and largely left to the person reviewing the content. Having a measurable way to assess quality, such as a minimum number of words or slides, may prove to be more beneficial in analyzing quality and consistency. The division of the lessons may be able to be improved; this improvement is entirely experimental, but if the lessons were divided or combined in a different way, it may have allowed for more in-depth coverage or coverage of more topics. Finally, the lessons could have done more to focus on career aspects that a given technology or lesson carries with it. The career discussion was often minimal, so increasing this to discuss possible careers, even if it is only one slide, could increase interest and buy-in significantly.

Finally, there are some personal improvements to be made on the project. First, an increase in collaboration would allow for better capitalization of the benefits which come from multiple people working together. For example, increasing the number of STEM teachers that were contacted to review and provide feedback on the lessons, or even including them from the start to better identify what they would want to see, may have provided a better final product. Additionally, ensuring that all priorities and responsibilities one may have are assessed and

aligned would improve workflow, efficiency, and accountability while decreasing stress. Often, priorities were overlapping and conflicting during the course of the project, making certain tasks more difficult than they needed to be. Taking the time to survey the responsibilities and prioritize would have eased the process significantly. This is a lesson to carry into the workforce as well as into personal life.

The next steps for this project are to continue gathering feedback on the information and products it survives to continuously improve the products for the benefit of all stakeholders involved. Beyond this constant improvement, the project will be tested in a few select schools with a sample of students in STEM classes to assess their opinions on the class and assess what they got out of it. From there, the project will be revised where needed and, hopefully, implemented in schools in some fashion, even as an after-school program, especially for schools with limited resources that rely on free or cheap tools. The lessons and project will also be available for free online for anybody to access and learn about IT and wireless network. Over time, more lessons than the existing five covering more topics will be added.

Presenting the Project

This project will be presented to the public a minimum of three times. It has already been presented publicly on Twitch and LinkedIn Live, and will be presented publicly on YouTube Live in the coming days. These presentations are to show off the project and garner feedback and criticism, which will then be used to improve the project even further. These platforms were selected because of the vast diversity of viewers amongst them; Twitch often has younger audiences and audiences interested in technology, while LinkedIn has professionals. YouTube has a great mix of audiences. Additionally, presenting the project at a local career and technical education expo is in the works, though this presentation would not take place until after May due

to timing issues; this expo will involve faculty from many local schools. The videos for the live public presentations, as well as the lesson resources, will be available in the links found in Appendix A.

Conclusion

This project was designed to educate high school students on various IT topics in wireless networking, which is becoming the new norm. The importance of IT education and the IT workforce has never been more highlighted than now; therefore, this lesson was also designed to spark interest in the field and encourage students to explore the field in any capacity, be it in the workforce or in higher education. The project created lessons to cover a variety of topics in wireless networking, and created accompanying hands-on activities to provide further education, experience, and interest. Overall, the project was a considerable success and taught many lessons to both the consumers and the producers. It will provide a considerable benefit to all stakeholder involved, especially as it continues to grow in effectiveness and reach.

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Appendix A

Twitch public presentation recording may be found here: <https://www.twitch.tv/wildgamety>

LinkedIn Live public presentation recording may be found here:

<https://www.linkedin.com/in/alexanderlhodges/>

YouTube Live public presentation recording and recordings for lesson one may be found here:

<https://www.youtube.com/channel/UCs7MrvsyWen0FeddU6Azzeg>

All documents and future recordings may be found in this Google Drive folder, which will be updated regularly: <https://drive.google.com/drive/folders/1yiW62OdkLriS5RzhMxRUb3OY9X-Y1Qqq?usp=sharing>

Other documents submitted include:

Project Charter

Lesson Outline

Instructor Notes

Lesson 1 Slides and the correlating video

Lesson 1 Hands-On Activities and the correlating video