

May 2016

Innovative Education and Classroom Design at Colegio Tecnico Profesional de Santa Ana

Mark Cipriano DeVries
Worcester Polytechnic Institute

Mila Monique Maynard
Worcester Polytechnic Institute

Peter Donald Melander
Worcester Polytechnic Institute

Victoria Lynn Simpson
Worcester Polytechnic Institute

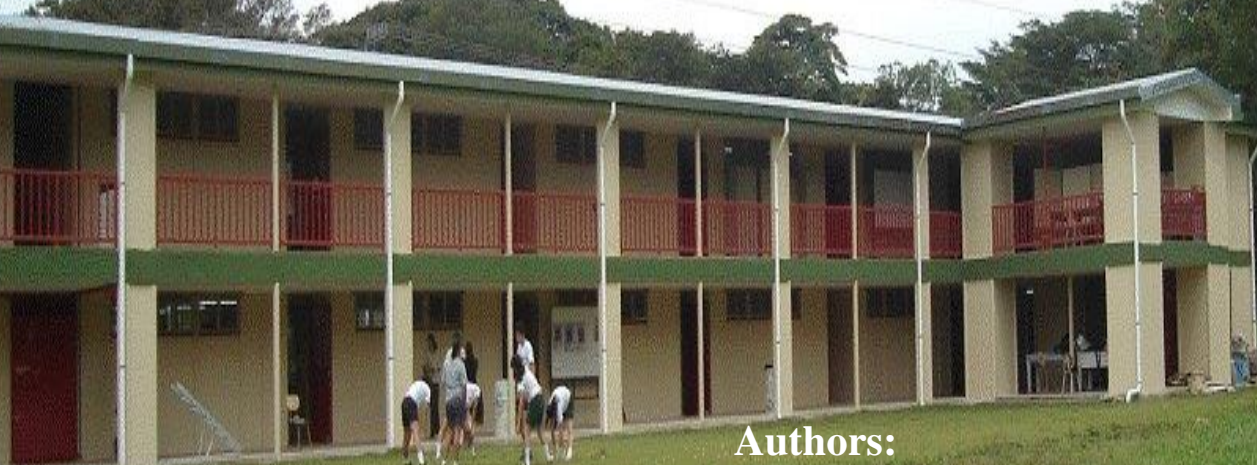
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Innovative Education and Classroom Design at Colegio Técnico Profesional de Santa Ana



Authors:

Mark DeVries.....Industrial Engineering ('17)
Mila Maynard.....Mechanical Engineering ('17)
Peter Melander.....Aerospace Engineering, Physics ('17)
Victoria Simpson.....Civil Engineering ('17)

Advisors:

Melissa Belz, PhD.....Interdisciplinary and Global Studies Division
Derren Rosbach, PhD.....Civil and Environmental Engineering

Sponsor:

Colegio Técnico Profesional de Santa Ana.....San José, Costa Rica

Date Submitted: May 1, 2016

San José, Costa Rica Project Center

Innovative Education and Classroom Design at Colegio Técnico Profesional de Santa Ana

An Interactive Qualifying Project submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE in partial fulfillment of
the requirements for the Degree of Bachelor of Science

By:

Mark DeVries
Mila Maynard
Peter Melander
Victoria Simpson

Date:

May 1, 2016

San José, Costa Rica Project Center
Report Submitted To:

Sergio Sepulveda
Ida Cortés
Colegio Técnico Profesional de Santa Ana

Professor Melissa Belz
Professor Derren Rosbach
Worcester Polytechnic Institute

Abstract

Innovation in schools provides new means to keep educational offerings up to date. Identifying unique and effective educational methods not currently utilized is an important first step in effective innovation. This project worked to initiate this process at Colegio Técnico Profesional de Santa Ana (CTPSA), a technical high school in San José, Costa Rica. We assisted in developing a Knowledge Management Center (KMC), a sustainable new building on campus that will provide space and resources to support student collaboration and connection beyond CTPSA. Through interviews, focus groups, and observations, we identified how collaborative teaching methods, flexible classroom design, and innovative resources outside of CTPSA can be implemented through the KMC to improve students' education.

Acknowledgements

Our team would like to thank the following individuals and groups for their help and support during our project:

- Sergio Sepulveda, our main contact at CTPSA
- Professor Melissa Belz and Professor Derren Rosbach, our project advisors
- Ida Cortés, President of the Administrative Board at CTPSA
- Renato Carranza and Fabiola Ruiz, for coordinating our visits to CTPSA
- Students and faculty at CTPSA, for participating in our focus groups
- All individuals who we interviewed in Costa Rica and at WPI, for providing us valuable information
- Worcester Polytechnic Institute, for providing us the opportunity to make a difference in Costa Rica

Executive Summary

A standalone version of this summary can be found in Appendix J.

Problem Statement

Innovation is vital in schools because it keeps educational offerings up to date with the demands of the world (Dlugash, 2014). Teachers and students are changing class structures to fit with the development of information and communication technology (Tamo, 2014). Schools are accessing larger collections of resources, both digital and physical, to innovate teaching and improve learning.

Colegio Técnico Profesional de Santa Ana (CTPSA), a Costa Rican technical high school in San José, is planning a new building called the Knowledge Management Center (KMC) to house space for student collaboration and resources for distant educational connections. The school is working to set an example for public technical high schools in Costa Rica by making the KMC innovative, environmentally sustainable, and inspirational to students.

The idea for this project originated when personnel associated with CTPSA identified that modern developments in education require that schools across the world are connected and benefiting from each other. Our project group had the opportunity to work closely with CTPSA to identify the best classroom resources, teaching methods, and design considerations that would further their educational mission and vision through the KMC.



Background

Three areas were of specific interest to our project: educational practices, learning resources, and environmental sustainability, which are outlined below.

Evolving Educational Practices

The traditional classroom is based on the Teaching-Centered Paradigm, where a lecturing instructor transfers knowledge to passive, note-taking students (McManus, 2001). In contrast,

modern teaching ideas center lessons around students by letting them guide discussions and collaborate with each other. Collaborative learning improves communication skills by providing opportunities to formulate and share ideas, which is a vital step in real world preparation.

Student and teacher roles in the modern style of teaching and learning are changing in that students are becoming more involved in the learning process, and teachers are viewed more as support for students.

Developing Appropriate Educational Resources

Modern schools require various resources to facilitate a diverse range of activities used to prepare students for college and the workforce. In particular, modern libraries serve as a centralized location where students can access databases of reading material, relevant software, and technological hardware to connect with students around the world.



Modern classrooms also need to be flexible and accommodate many different activities. Flexibility aids the learning process by allowing a space to quickly be set up for any given activity, satisfying the needs of all students.

Sustainable Development

Costa Rica has made a commitment to carbon neutrality by 2021, and it is important for schools across the country to commit to sustainability in designing and evolving new facilities (Edwards, 2014). Sustainability can be implemented into building design without compromising the functionality of the building, and can also focus on involving students to positively impact future generations (“Teaching Sustainability,” 2016).

Project Objectives

The goal of this project was to develop the framework for a sustainable and flexible collaborative learning space at Colegio Técnico Profesional de Santa Ana (CTPSA) that would encourage students to learn and expand their educational possibilities. To achieve this goal, we developed and completed the following four objectives:

1. Determine classroom resources and teaching methods currently in place at the school and evaluate student and teacher satisfaction with them
2. Investigate effective educational and sustainability initiatives already being implemented both in Costa Rica and internationally
3. Assess various educational and sustainability options in the scope of CTPSA's financial conditions and curricular goals
4. Develop a comprehensive plan that identifies subsequent steps the school can take to realize their flexible and sustainable learning space

Methods

Our group used action research which involves social engagement and challenging what is accepted as normal with the intent of improving a social issue. The data for this problem solving includes interviews, focus groups, observations, participant observations and accounts (Marelli, 2016).

We used focus groups of faculty and students and classroom observations to learn about CTPSA's current teaching methods and identify the use of collaboration and technological learning materials in the classroom. To gain a perspective of teaching methods and specific materials students use in classrooms outside of CTPSA, we toured and interviewed administration at another technical high school in Costa Rica and held interviews with teaching and learning personnel from Worcester Polytechnic Institute. Lastly, to investigate sustainability considerations for the KMC, we toured a sustainable campus in Costa Rica and interviewed individuals who specialize in implementing sustainability into buildings in tropical climates.

Outcomes

Assessment of CTPSA Reveals Potential for Improvement

The first work we did in Costa Rica was to familiarize ourselves with CTPSA's current educational practices, resources, students, and faculty. Speaking with our focus groups revealed that students and teachers are grateful for CTPSA's educational offerings but also ambitious in wanting to make improvements. Students and teachers



identified that their classes are impeded by a lack of sufficient computers, audio recording and playback equipment, and books.

We recommended that CTPSA contact companies and institutions that donate relevant resources, and we outlined the process for contacting many of these specific organizations.

Proper Use of Resources Outweighs Quality of Resources

State-of-the-art resources serve no purpose if they are not used properly. We saw resources at CTPSA being used to their fullest potential even though they could be deemed obsolete, but also observed inefficient use of technology at multiple schools. The KMC is going to have innovative and valuable resources for teachers and students, but they will only be effective if they are used effectively by the school.



Improved Internet Promotes Innovation and Facilitates Connections

Internet is already an important resource at CTPSA, and it will become even more critical with the addition of the KMC. The quality of the current internet connection at the school is limiting the ability of teachers to incorporate online resources into their classes and the ability of CTPSA to make connections with other institutions.

CTPSA has the potential to improve its internet. Nationally, Costa Rica is continuing to improve internet for its citizens, and short term and long term improvements to internet infrastructure at CTPSA are possible as the school progresses towards the KMC (Agüero, 2016).

Multifunctionality is Key in the KMC

The KMC will differ from academic classrooms in that it will be used by every student and teacher, so it has to have features that are adaptive and useful for a variety of activities. The spaces should benefit each student equally although they use the space differently.

Lightweight and movable yet sturdy tables and chairs make it easy for teachers and students to manipulate a space to fit their needs, and a variety of workspaces allows for easy student cooperation. Since the KMC will have limited space but house many activities, multifunctionality is essential in its design and operation.

Design Freedom Allows for Sustainability

As CTPSA works with Katia Marten Arquitectos on the design of the KMC, it has been given the unique opportunity from the government to formulate a unique and sustainable but still functional building design. Cross ventilation, natural illumination, and vegetation are sustainable design considerations that are appropriate for the climate in San José which work to reduce electricity usage and conserve natural resources.

Alternative energy could be used to help power the KMC, while other design considerations will allow the building to passively benefit from the environment. Keeping these considerations in the forefront of the design of the KMC will not only preserve the environment but also benefit its functionality.



Conclusion:

The importance of education has made this project an exciting opportunity for our group to make a difference in the education of a very special group of students. From the beginning of our research, our priority was to work successfully with Colegio Técnico Profesional de Santa Ana (CTPSA), allowing them to be involved in decisions regarding improvement of their school. As CTPSA continues to grow, the school seeks to have a building that can further strengthen their young professionals' practical technical capabilities. They wish to achieve it through a multifunctional learning space that incorporates local and distant collaboration to improve problem solving skills that will be known as the Knowledge Management Center (KMC). We hope that through our research and recommendations, CTPSA will accomplish their goal of designing the KMC to be geared to strengthen its students' education with practical, appropriate, and sustainable technology.

“School improvement is a process, not an event. It takes place over an extended period of time, usually several years” (van den Berg & van Velzen, 1985, p. 59). This is the case for the KMC. We came to Costa Rica knowing that we must work within a reasonable scope, and the work we have done will serve as a solid foundation for CTPSA to accomplish their goal of the KMC. We are confident that future work by CTPSA faculty and outside volunteers will extend our recommendations, ultimately ending in the successful implementation of a new innovative, sustainable learning space.

Authorship

MD – Mark DeVries PM – Peter Melander	MM – Mila Maynard VS – Victoria Simpson	Primary Author(s)	Primary Editor(s)
Abstract		All	All
Acknowledgements		PM	All
Executive Summary		All	All
Problem Statement		PM	All
Background		MD, MM	All
Evolving Educational Practices		MD	All
Developing Appropriate Educational Resources		MD	All
Sustainable Development		MM	All
Project Objectives		All	All
Methods		MM, VS	All
Outcomes		All	All
Assessment of CTPSA Reveals Potential for Improvement		PM	All
Proper Use of Resources Outweighs Quality of Resources		MD	All
Improved Internet Promotes Innovation and Facilitates Connections		PM	All
Multifunctionality is Key in the KMC		VS	All
Design Freedom Allows for Sustainability		MM	All
Conclusion:		All	All
Authorship		PM	All
Chapter 1: Introduction		All	All
Chapter 2: Background		All	All
2.1 Evolving Educational Practices		PM, VS	All
2.1.1 The Traditional Classroom		PM	All
2.1.2 Fostering Effective Learning with Collaboration		PM, VS	All
2.1.3 Evolving Student and Teacher Roles		VS	All
2.2 Developing Appropriate Educational Resources		MD, PM	All
2.2.1 The Modern Library as a Means of Centralization		PM	All
2.2.2 Openly Available Resources		PM	All
2.2.3 Resources to Support Collaboration		PM	All
2.2.4 Modern Classroom Spaces		MD	All
2.3 Colegio Técnico Profesional de Santa Ana		MD, MM	All

2.4 Sustainable Development	MD, MM	All
2.4.1 Sustainable Design and Building Process Considerations	MM	All
2.4.2 Getting Students Involved in Sustainability	MD	All
Chapter 3: Methodology	All	All
3.1 Objective 1: Determine classroom resources and teaching methods currently in place at the school and evaluate student and teacher satisfaction with them	MM, VS	All
3.1.1 Focus Groups	VS	All
3.1.2 Determine the Teaching Methods at CTPSA	MM	All
3.2 Objective 2: Investigate effective educational and sustainability initiatives already being implemented both in Costa Rica and internationally	MM	All
3.2.1 Evaluation of Educational Practices and Resources	MM	All
3.2.2 Sustainability in Costa Rica - EARTH University Visit	MM	All
3.3 Objective 3: Assess appropriate educational and sustainability options in the scope of CTPSA's financial conditions and curricular goals	PM	All
3.3.1 Current Architecture Plans for the KMC	PM	All
3.3.2 Research for Online Resources	PM	All
3.3.3 Value Analysis of Resources	PM	All
3.4 Objective 4: Develop a comprehensive plan that identifies subsequent steps the school can take to realize their flexible and sustainable learning space	MD	All
3.4.1 Format of Results	MD	All
3.4.2 Understanding the Process	MD	All
3.4.3 Resource Funding and Donations	MD	All
Chapter 4: Findings	All	All
Finding 1: Teachers and students at CTPSA are limited by currently available technology and physical resources.	MD	All
Finding 2: Using available resources effectively is just as important as having them being state-of-the-art.	All	All
Finding 3: Securing a reliable internet connection at CTPSA is critical to promoting innovation and preventing isolation.	PM	All
Finding 4: Multifunctionality in any new space at CTPSA is critical to accommodate a complex set of students' needs.	VS	All

Finding 5: CTPSA has the unique opportunity to incorporate realistic and functional sustainability considerations into the design and operation of the Knowledge Management Center.	MM	All
Limitations	PM	All
Chapter 5: Recommendations	All	All
5.1 Internet Connectivity	PM	All
5.2 Backup Power	MD	All
5.3 Classroom Setup and Resources	MD, PM, VS	All
5.3.1 Photocopier	MD	All
5.3.2 Power and Ethernet	PM	All
5.3.3 Computers	MD	All
5.3.4 Software	PM	All
5.3.5 Headphones and Speakers	MD	All
5.3.6 Books	VS	All
5.4 Teaching Methods	MD	All
5.5 Networking Opportunities, Connections, and Alliances	VS	All
5.5.1 Websites and Social Media	PM	All
5.6 Building Design	MM	All
5.6.1 Illumination	MM	All
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I.2 Backup Power - Generator Options	MD	All
I.3 Photocopier Guide	MD	All
I.4 Furniture and Classroom Setup Recommendations	PM	All
I.5 Computer Donation Organizations	VS	All
I.6 Free Software for Implementation	PM	All
I.7 Audio and Recording Equipment for English learning	MD	All
I.8 Book Donation Organizations	VS	All
I.9 Networking Opportunities, Connections, and Alliances	PM, VS	All
I.10 Selecting and Implementing Solar Panels for the KMC	MM	All
I.11 LED Lighting Opportunities in Costa Rica	MM	All
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Chapter 1: Introduction

Education from a global perspective is continually evolving. In schools, teachers and students are changing class structures to fit with the development of information and communication technology (Tamo, 2014). Schools are focusing on both innovation and globalization. Innovation in schools is vital because it keeps educational offerings from becoming outdated (Dlugash, 2014). Meanwhile, globalization, defined as “the increased interconnectedness and interdependence of peoples and countries,” gives the opportunity to connect schools and create a network of resources and ideas that can positively benefit students (“Globalization,” 2010; Williamson, 2013).

Costa Rica, which, while not defined as a developing country by the United States Economic Development Agency, is a country with notable rural and underprivileged areas (Dyer, 2014; “EDA Developing Countries List for AY 2014/2015,” 2016). Schools in rural areas do not necessarily have access to collections of modern educational resources, both physical and digital. Such schools can, however, improve student learning through efforts to adapt and innovate available educational resources. Initiatives to increase technology use and give space for collaboration can allow students to thrive even in a potentially limiting environment.

Educational institutions are looking to continue developing students’ cognitive and critical thinking skills through collaborative learning. As James Watson, co-discoverer of the double helix DNA molecule, once said, “Nothing new that is really interesting comes without collaboration” (Johnson, Johnson, & Smith, 1998, p. 28). Collaborative learning aims to support active student involvement in learning and improves communication skills by giving students opportunities to formulate and share ideas. Additionally, due to globalization, collaboration can expand beyond the classroom. Advanced teaching techniques and new ways to use learning spaces facilitate collaboration and help to keep students engaged and motivated. These innovative learning approaches require that classrooms are flexible to accommodate collaboration.

Colegio Técnico Profesional de Santa Ana (CTPSA) is a Costa Rican government-owned technical high school that gives students who may not go to college an opportunity to attain a technical degree. They hope to add a new building to their campus, which will be known as the Knowledge Management Center (KMC). Knowledge management, within schools, is an idea about collection and collaboration of resources to maximize student success (Cheng, 2014).

Innovation and interconnectedness are both very important aspects of knowledge management, since it emphasizes both the importance of using available resources effectively and the potential of collaboration among different organizations. The KMC will act as a modern library to enable knowledge management, and it will house an array of educational resources as well as provide innovative space and materials for collaboration and group work.

Costa Rica has made a pledge to become carbon neutral by 2021, and CTPSA wishes to contribute to this trend of sustainability in the design and operation of its new building (Edwards, 2014). Costa Ricans take pride in preserving natural resources and can receive “economic, environmental, and societal benefits” for sustainable design (Kampschroer, 2009). Green buildings at schools like CTPSA also help to initiate environmental awareness in students.

We were asked by CTPSA to bring in a new perspective to the development of the KMC. Our main purpose was to work closely with CTPSA to recommend options for both construction of a sustainable building and resources to support innovative education and collaboration within it. Our objectives to accomplish this goal included (1) determining classroom resources and teaching methods currently in place at the school and evaluating student and teacher satisfaction with them, (2) investigating effective educational and sustainability initiatives already being implemented both in Costa Rica and internationally, (3) assessing various educational and sustainability options in the scope of CTPSA’s financial conditions and curricular goals, and (4) developing a comprehensive plan that identifies subsequent steps the school can take to realize their flexible and sustainable learning space.

This report is divided up into five chapters, including this introduction. In chapter two, we give a background of relevant literature in the areas of educational methods, classroom resources, and sustainability. In chapter three, we develop our goal, expand on our four objectives, and identify the methods used to complete them. In chapter four, we share our findings that we have determined as a result of analyzing the information gathered through research, interviews, focus groups and observations. In chapter five, we use our findings to provide our recommendations on how to properly prepare for the implementation of the KMC as well as how to appropriately utilize the KMC after its construction.

Our analysis has resulted in findings including that a lack of technology and physical resources limits students and teachers at CTPSA. Several key observations also revealed that proper utilization of resources is vital for schools with a limited budget. Additionally, we found

that the current internet connection at CTPSA is not sufficient to support desired use of technology in the classroom. The variety of activities that will be housed in the KMC demonstrated the need for multifunctionality to be an important consideration its development. Lastly, we found that CTPSA has more creative freedom than other public technical high schools for designing new buildings, which allows them to incorporate a range of sustainability initiatives into the design, construction, and operation of the KMC. Based on these findings, we made specific recommendations to CTPSA that we believe will give them the best opportunity to successfully build and effectively utilize the KMC on their campus.

Chapter 2: Background

The modern school is a multi-dimensional entity, encompassing both innovative physical resources and educational philosophies. In the rapidly developing world, schools that do not fit this modern, innovative framework are limiting students from full achievement (Miles, 2015). Education is vital for world development, so it is in the best interest of schools to continuously evolve ("Why is Education for All So Important?" 2009). This is supported by the findings of Jane Best and Allison Dunlap, who found that “schools and districts incorporating continuous improvement into their work have shown promising results” (Best & Dunlap, 2014, p. 5). Unfortunately, even if schools are aware of the need to develop, the process to do so is not always obvious. A key first step in the process is for schools to develop a complete knowledge of new educational ideas and then use that knowledge to better student learning.

In this chapter, we review factors affecting modern school development and discuss modernization efforts already in place in schools. Section 2.1 discusses educational practices within the classroom and the continued development of educational methods to meet the needs of students. Next, section 2.2 examines how educational resources facilitate modern learning processes. Section 2.3 introduces the Colegio Técnico Profesional de Santa Ana (CTPSA), our sponsor, and discusses their current capacity and their desire and means to modernize. Finally, section 2.4 connects the modern school and the positive world attitude towards sustainability.

2.1 Evolving Educational Practices

According to Collins and Halverson (2009), modern technology enthusiasts see schools as places where students must take on real world problems, depend on each other, and utilize adult instructors as supporters to the learning process. This vision represents a shift in educational philosophy from what Dean McManus of the University of Washington refers to as the “Teaching-Centered Paradigm” to the “Learning-Centered Paradigm” (McManus, 2001). There are very few people who would argue that school today is the same as it was 100, 50, or even 10 years ago, and looking backward rather than looking forward in educational methods will not result in effective student learning.

2.1.1 The Traditional Classroom

An important concept in modern education is that of the traditional classroom setting and how it differs from education today. The traditional classroom philosophy centers on teachers as

the all-knowing presence and students as uninformed dependents ("Differences Between Traditional and Progressive Education," 2016). McManus's Teaching-Centered Paradigm is the essence of the traditional classroom, where "students are assumed to enter the course with minds like empty vessels or sponges to be filled with knowledge" (McManus, 2001, p. 424). Another factor in the traditional classroom is negative interdependence among students, meaning students develop a negative association of their fellow students. The traditional classroom fosters competition among students, which, while having the potential to promote positive learning, also makes "most students perceive school as a predominantly competitive enterprise" (Johnson, 1984, p. 2). With the potential for such a negative collective attitude among students, other classroom philosophies aim to develop more positive relations among students.

2.1.2 Fostering Effective Learning with Collaboration

Alternative and innovative educational practices exist to eliminate harmful competition among learning colleagues. In particular, if "students work by themselves to accomplish learning goals unrelated to those of the other students," they only have themselves to compete against, which depending on the student can be motivating or limiting (Johnson, 1984, p. 2). Johnson notes that this *individualistic* education has been prevalent in schools over the last half of the 20th century. Furthermore, there is another learning structure, where students work with one another in groups to accomplish a common goal. This learning structure, known as collaborative learning or cooperative learning, is a structure in which students work with one another to achieve a shared objective. Johnson argues that collaborative learning fosters a "positive interdependence among students' goal attainments; students perceive that they can reach their learning goals if and only if other students in the learning group also reach their goals" (Johnson, 1984, p. 2). Students benefit in a number of ways from collaborative learning. Lotfi, Nasaruddin, Hanum, Sahran, & Mukhtar (2013) emphasize that "cooperating with peers encourages critical thinking, develops higher level of cognitive skills and sharpens communication skills" (p. 23). Educational practices exist that advance the collaborative approach.

Project-based learning, closely related to problem-based learning, has emerged as an educational mechanism within collaborative learning. It is a student-centered method of teaching that improves knowledge through collaboration and self-directed learning to develop problem solving skills that are closely related to the real world work environment (Abubakar &

Arshad, 2015). The problem solving skills that are developed through project-based learning are more closely related to the real world work environment. Practical, real world education is growing in importance, putting students who work in a collaborative, problem-based setting ahead of those who only learn through traditional methods.

2.1.3 Evolving Student and Teacher Roles

Although collaborative and project-based learning offer great potential, they do not immediately guarantee students' success. Because both students and teachers are accustomed to the traditional classroom, many are not immediately comfortable with the collaborative learning style (Johnson, Johnson, & Smith, 1998). Often teachers are not trained to work in the collaborative classroom, which limits the effectiveness of collaboration. Collaborative learning can be mistaken for just simple and superficial group work, and "simply assigning students to groups and telling them to work together does not in and of itself result in cooperative efforts" (Johnson, Johnson, & Smith, 1998, p. 28). To change the student-teacher dynamic from that of the traditional classroom, teachers must assume a new role in the collaborative classroom environment. Instead of simply continuously feeding information through lectures, teachers need to present information in an inquiry-based way. This means that students should be encouraged to ask questions and help shape the "content, direction, and pace" of their classes (McManus, 2001, p. 426). Building genuine trustworthy relationships between teachers and students is vital to the student's capacity to learn. Trust helps to validate a student's feelings and provides an environment where they are comfortable taking risks, making mistakes, and saying "I don't get it!" when they don't understand a certain topic (Bruney, 2012). There must be an equal emphasis on the content, learning process, and classroom environment in the modern school so that students can reach their full potential.

2.2 Developing Appropriate Educational Resources

With the progress of modern educational practices, it is crucial for schools to have resources necessary to implement these practices. Collins and Halverson (2009) discuss that all schools face an immense challenge in adapting to and surviving in the world's new technological and perpetually globalizing environment. They note that this challenge is twofold, requiring schools to both improve old resources and construct new resources. Learning materials must be practical and available to best promote student learning. This section explores various resource

possibilities in schools, how they are being implemented, and the possible drawbacks of these resources.

2.2.1 The Modern Library as a Means of Centralization

The existence of a modern library within the modern school is imperative. The modern library offers more than just the print books of the world's classic, long-established libraries. Resources including online materials, advanced technology, adaptive spaces, and supportive personnel are centralized in modern libraries, making them extremely useful and accessible to students (Huang, 1993). A study by Haddow (2013) showed a strong correlation between library access and student retention in schools. While student retention is much more relevant at the postsecondary level as compared to the secondary level, the study suggests that there is a correlation between library use and positive student achievement. Due to this connection, it is advantageous for modern schools to find ways to give their students access to a diverse array of resources. It is worth noting, however, that giving students access to modern library resources does not guarantee that they will use those resources to their full potential, but not having access to adequate resources will limit student success (Benford & Gess-Newsome, 2006).

2.2.2 Openly Available Resources

The effectiveness of the modern library has seen great progress with the free availability of educational resources. Free resources are better than paid resources for schools with limited funds because they do not have the financial means to buy access to resource bases. Free resources are diverse in the sense that they span from websites of useful information for school projects to free software that enhances student learning. Specifically, two free initiatives work to grant free access of educational resources to students through the internet. Online Educational Resources (OERs) provide the opportunity to give more secluded communities wider access to an assortment of educational resources (Larson & Murray, 2008). As an extension of OERs, Massive Open Online Courses (MOOCs) provide a way for students to supplement the education they get in school (Oliveira, Aureliano, de França, & Tedesco, 2014). Essentially, the intent of OERs is to give general resources to students while the intent of MOOCs is to supplement specific courses and even give students the option to learn courses on their own. One of the most well-known MOOC resources is the OpenCourseWare series from the Massachusetts Institute of Technology in Cambridge, Massachusetts ("MIT OpenCourseWare," 2016). These resources

provide countless students with the means to learn courses that they are interested in and supplement courses they are learning elsewhere.

While there are certainly advantages in the OER and MOOC movement, there are also potential hindrances. For example, depending on school location, OERs and MOOCs may be very difficult to access due to internet limitations. As put by Larson & Murray (2008), “An inadequate [Information and Communication Technology] infrastructure is a major obstacle to the dissemination and use of all OER[s]” (p. 91). If more advanced communities have access to a wealth of OERs and MOOCs online, it only allows them to get further ahead of communities that are still struggling to gain access to these resources. The idea of inadequate infrastructure is important to recognize as a barrier of rural and developing communities to school improvements in general. Schools that lack adequate financial means for improvement are at an inherent disadvantage compared to schools with ample supplies of resources and money (Camera, 2016). Another potential disadvantage of online educational material is lack of human interaction (Hickey, 2014). MOOCs and OERs have no personal interaction and are produced long before a student uses them. As a result, if a student does not understand the explanation of an internet resource, he or she has potentially hit a dead end. On the other hand, a student interacting directly with an instructor has a greater capability to ask questions until he or she understands a concept.

2.2.3 Resources to Support Collaboration

As was previously mentioned, cooperation within a class builds advanced networks of knowledge. As a result, schools that aim to encourage collaborative learning must provide resources to connect students not only to other students but also to other schools and institutions. At the very basic level, technology is necessary to connect classrooms in different schools. The use of computers, webcams, phones, and the internet makes collaboration halfway around the world an instant luxury. In particular, social media is developing as a viable means of making this connection. As put by English teacher and instructional technology coach Brianna Crowley, “Connected classrooms can reach beyond physical barriers to create conversations with people from other classrooms, cultures, and communities. Social media provides venues for students to share their stories both within and beyond the classroom” (Crowley, 2016). Social media can instantly join students across the world in collaborative projects.

2.2.4 Modern Classroom Spaces

In order to achieve goals of collaboration in the classroom, it is necessary to consider the configurational differences of a collaborative learning space from a traditional classroom. The physical environment of the classroom can have a profound impact on how effectively students learn. A study done in Blackpool, England by faculty from the University of Salford School of the Built Environment looked at ten physical aspects of a classroom and determined that six had significant impacts on student learning (Vanhemert, 2013). Notably, flexible classrooms, or classrooms that could better accommodate students without crowding them and could easily be rearranged to support a variety of activities, had a positive effect on student learning and achievement. Flexibility is essential in a multi-purpose building used for a wide range of daily activities, including many that involve collaboration. Additionally, furniture choices in the classroom affect student learning. There was also a positive correlation between schools providing ergonomic and high-quality furniture in their classrooms and their students' achievement level. Having this furniture makes the room more attractive to students while allowing the space to be easily manipulated for a variety of activities. Lack of moveable furniture results in the furniture setup dictating activities in the classroom instead of teachers and students having the ability to rearrange the setup to fit a desired purpose. The Salford School study shows that something as seemingly minor as choice of chairs can significantly impact students' abilities to learn by giving them a more inviting and flexible learning environment. In the workspaces of a modern library, these considerations are important to allow collaborative work of varying group sizes, informal study, and individual work at any given time (Seal, 2015). Education in these spaces can then better fit the specific, developing needs of all students.

Consciousness of the importance of classroom layout is only the first step in creating a proper classroom environment because the school's specific needs must still be considered. Educators must look at several different models and combine them to come up with a solution that will give students the best opportunity to learn. The Center for Teaching and Learning at the University of North Carolina (UNC) Charlotte provides information specifically regarding the setup of a collaborative learning space ("Collaborative Learning Spaces," 2016). First, it is extremely important to have means of displaying work as well as having plenty of writing surfaces. This means that the room should have multiple television screens or projector screens along with several magnetic white boards, cork boards, and horizontal surfaces to display



Figure 1. Flexible learning space at the Monterrey Institute of Technology and Higher Education in Mexico City (Thelmadatter, 2014)

material and write on. Including these options in a classroom allows students to easily work together and share their work with everyone in the class. UNC Charlotte also highlights the importance of furniture decisions when designing a classroom by giving numerous suggestions on furniture that supports and encourages collaboration. The most important feature of the furniture is that it is lightweight so that it can be easily manipulated to meet the specific needs of each class. Figure 1 shows a classroom at the Monterrey Institute of Technology and Higher Education, a school in Mexico City, which incorporates many of the characteristics discussed in this section. The room is visually appealing for students because of the colors of the chairs, and it is easily configured into different group sizes due to the wheels on all the chairs and tables. The room also includes many different writing surfaces that can be moved around the room as needed. There are many factors present when designing a classroom in a modern school, some more obvious than others, but all are equally important to consider before determining the final layout. These factors must be taken into account as CTPSA moves forward with their design for a new collaborative learning space.

2.3 Colegio Técnico Profesional de Santa Ana

Technical education is important in Costa Rica, as it is an accessible option for those looking to enter the workforce directly after high school (“Technical Education”, 2016). Since the founding of Colegio Técnico Profesional de Santa Ana (CTPSA) in San José, Costa Rica in 2004, the secondary school (grades 10-12) has continued to grow and flourish as a technical institution. The school offers three specialties in which its students can focus: Accounting, Computer Networking, and Executive Services. With 450 students in total, this government-owned school teaches day and night classes that prepare their students for the workforce (“CTP Santa Ana,” 2016).

CTPSA seeks to expand and innovate by building a Knowledge Management Center (KMC) to help give more opportunities to their students. The KMC will be a modern library that helps develop critical thinking and problem solving abilities. Not only will their KMC allow the school to supply resources to help students become more prepared for their classes and projects, but it will also offer students a way to connect with other schools around the world. The KMC will help CTPSA students develop professional and social skills that can benefit them when they enter the workforce.

As the school guides students towards certain professional concentrations, they also instill a responsible attitude towards the environment and its valuable resources through the Blue Flag Program. The Blue Flag Program is a project that promotes an environmentally conscious mindset to the students and teachers of the school (“Bandera Azul”, 2016). Sustainability as it relates to schools is discussed in the next section, and CTPSA already makes considerable sustainable efforts. Because of the value placed on environmental responsibility in the school, CTPSA wants to make sure that the KMC explores various sustainability options in design, construction, and operation.

2.4 Sustainable Development

Many communities worldwide are dedicating efforts to sustainability (“Sustainable Cities Initiative,” 2016). As a result, it is in the best interest of schools in these communities to commit to sustainability in designing and evolving their new facilities. Sustainability as a concept has many different meanings. One helpful interpretation of sustainability, of interest to schools attempting to grow, comes from the United Nations Report of the World Commission on Environment and Development, stating that “Sustainable development is development that meets

the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland et al., 1987, p.54). Annie Pearce, Yong Ahn, & HanmiGlobal (2012) extend this idea by arguing that with sustainability and sustainable development, the world is “able to continue or persist indefinitely without depleting resource bases or damaging natural ecosystems” (p. 469). Different countries have taken on different levels of commitment to sustainability, as certain countries’ economies and lifestyles rely heavily on the environment. (Chen, 2015; Blersch & Kangas, 2013). A significant commitment to sustainability is noted in Costa Rica, as the country has committed to becoming carbon neutral by 2021 (Edwards, 2014). This section outlines various ways in which buildings can be designed efficiently and students can become involved with sustainability.

2.4.1 Sustainable Design and Building Process Considerations

Technology has led to new design options for building materials. With a sustainable mindset, there are new ways to implement intelligent materials and increase efficiency of buildings. There have been significant advances in formulation, composition, and installation of building materials leading to decreased environmental impact (Pearce, Ahn, & HanmiGlobal, 2012, p. 428).

Designing sustainably goes beyond using renewable energy. When considering tropical eco-friendly building design, it includes low-maintenance construction, local material and labor usage, and climate awareness (McCabe, 2016). In an interview for the Tico Times, architect Bruno Stagno of San Jose’s Instituto de Arquitectura Tropical emphasized that adapting architecture design with respect to the environment and climate is important. He said that “Often, the difference between a wasteful building and an environmentally friendly one comes down to small features ... Especially in areas that experience extreme temperatures, details such as adding an overhang to reduce sunlight on a glass surface, or adding windows to allow for greater air circulation, can save thousands of dollars in energy bills” (Stanley, 2006, para. 14).

2.4.2 Getting Students Involved in Sustainability

“Living sustainably is about changing our attitudes in a way that helps transform our lives into something that doesn’t impact too heavily on our current routines, while using the planet’s resources in moderation” (Nayar, 2013). Depletion of natural resources is a worldwide problem, and student awareness can have an important impact on current and future generations (“Teaching Sustainability,” 2016). Student involvement in sustainability is important to ensure

that a school functions with minimal impact on the environment. Schools can show their students how different behaviors impact the environment and thereby guide them to live sustainably. Students also benefit from this knowledge because they keep the environmental mindset and habits they form as children throughout their lives (Smith, 2014). Giving students the opportunity to take an active role in sustainability at their school is a simple and inexpensive way to conserve natural resources.

There are innovative schools that already embrace the mindset of student involvement in sustainability. Oberlin College in Ohio created a student organization that examines the school's environmental impact and looks into ways to minimize that impact. This self-inspection is a great way to get students involved in reducing the environmental footprint of their school ("Oberlin College Resource Conservation Team," 2016). Additionally, Brandeis Hillel Day School in San Francisco, California has numerous sustainable practices that have positively impacted their school ("Green Schools Initiative," 2016). Specifically, they intend to eliminate waste by recycling and composting all possible materials. Schools like CTPSA can learn from other schools' successful programs and environmentally friendly designs.

Our group worked with Colegio Técnico Profesional de Santa Ana to help them utilize modern resources to advance student achievement. Specifically, we assisted in making the functionality of their KMC fit the needs of their students. We also ensured that the school has options to build and equip the KMC that are both financially realistic and functionally appropriate. Finally, we helped the school support Costa Rica's sustainable focus by suggesting ways to minimize their school's impact on the environment. *Going Green* and *Living Sustainably* are overused in today's society, but by researching and learning from experts in the environmental sciences field we were able to give CTPSA realistic and effective ways to minimize the KMC's impact on the environment. Our project involved gaining insight into opportunities for CTPSA to properly build and implement the KMC into their campus. The following chapter will outline in more depth our project goal, our distinct objectives to reach the goal, and our methods to complete the objectives.

Chapter 3: Methodology

The goal of this project was to develop the framework for a sustainable and flexible collaborative learning space at Colegio Técnico Profesional de Santa Ana (CTPSA) that would encourage students to learn and expand their educational possibilities. To help us achieve this goal, we developed the following four objectives:

1. Determine classroom resources and teaching methods currently in place at the school and evaluate student and teacher satisfaction with them
2. Investigate effective educational and sustainability initiatives already being implemented both in Costa Rica and internationally
3. Assess various educational and sustainability options in the scope of CTPSA's financial conditions and curricular goals
4. Develop a comprehensive plan that identifies subsequent steps the school can take to realize their flexible and sustainable learning space

These objectives, while all independent, are also quite related. The following sections explain each objective in more detail, specifically addressing what we needed to learn, why we needed to learn it, and how we accomplished it. Overall, our research methods constituted action research, which focuses on social engagement and challenging what is accepted as normal with the intent of improving a social issue (Brydon-Miller, Greenwood, & Maguire, 2003).

3.1 Objective 1: Determine classroom resources and teaching methods currently in place at the school and evaluate student and teacher satisfaction with them

To create a more innovative and engaging learning environment for CTPSA, we first needed to understand what resources the students and faculty currently have access to and their satisfaction with those resources. It was important for us to know this information in order to develop and suggest sensible new advancements for the school. Through focus groups with the students and teachers, we determined the current and desired resources for the school. We also determined teaching methods at CTPSA through focus groups and classroom observations. To assure ethical interactions with interviewees and focus groups, we obtained approval from the Internal Review Board at Worcester Polytechnic Institute. We informed our interviewees and focus group members of the purpose of our study, and CTPSA's principal, Saúl Castañeda, signed a consent form for the participation of the students under the age of 18.

3.1.1 Focus Groups

Our team utilized a focus group of students in order to gain insight into the types of resources that they have and their opinions on those resources. Two faculty members at the school, English teacher Fabiola Ruiz and Technical Coordinator Renato Carranza, provided us with a group of twelve students for our focus group who we met with four times over the first five weeks of our work in Costa Rica. Four students came from each specialty (Accounting, Executive services, and Computer Networking), and all twelve students were in their second year at CTPSA. We utilized a focus group with just the students because, according to Berg and Lune (2012), “focus groups are an excellent means for collecting information from informants who might otherwise tend to go off on their own topics, such as young children and teens” (p. 166). Furthermore, by speaking to the same students on each occasion, we were able to have a more in-depth and meaningful discussion about their experiences and opinions related to education at CTPSA. We also proposed different ideas about new resources to our focus group to get feedback on how they thought the resources could benefit education at CTPSA.

We utilized a similar focus group with teachers and administration to receive their input on how the school currently runs and improvements that could be made. Members of this focus group were Mr. Carranza, Ms. Ruiz, English teacher Denia Sterling, Accounting teacher Edwin Montero, and Computer Networking teacher Otniel Penado. On one occasion, Computer Networking teacher Marco Gutierrez took the place of Mr. Penado. We wanted to gain feedback similar to what we gathered from students and gauge interest in the implementation of a new flexible learning space. As our ideas progressed, we discussed our intentions for the new building with the student and faculty focus groups to gauge reactions to the proposed changes. Our initial focus group questions can be found in Appendices A and B. Each meeting with a focus group was led by our project group, but we encouraged the respondents to expand on topics that were relevant to the particular conversations. Additionally, each meeting lasted approximately one hour. Overall, we recognized that it is very important to have students and teachers involved in the improvement of their school, and our focus groups initiated this involvement.

3.1.2 Determine the Teaching Methods at CTPSA

During the student and faculty focus groups, we asked questions to identify teaching methods at CTPSA. To augment this information, we directly observed those teaching methods

by sitting in on classes. We wanted to see a variety of specialties and age groups, so Mr. Carranza and Ms. Ruiz arranged observations of a 10th grade beginner English class, an 11th grade Executive Services English class, a 12th grade Executive Services English class, a 12th grade Accounting class, and a 12th grade Computer Networking class. When we observed the classrooms, we looked at the use of collaboration; the use of computers, speakers and projectors; general student involvement; and the dynamic between students and teachers. The classes we observed were taught by the teachers in our focus group, so we were able to directly reinforce the focus group data and also identify additional classroom elements that could extend into the KMC.

3.2 Objective 2: Investigate effective educational and sustainability initiatives already being implemented both in Costa Rica and internationally

To determine possible areas of improvement in CTPSA's current sustainability and educational practices, we needed to know what was already being done both at the school and elsewhere. Our group looked into different options for building designs and initiatives that could minimize the impact of the building on the environment along with educational procedures and resources to assess the best way for CTPSA to use the KMC. We visited another Colegio Técnico Profesional to interview administration and learn about their experiences with resources that are relevant to CTPSA. We also conducted interviews with Teaching and Learning Center Director at Worcester Polytechnic Institute (WPI), Chrysanthe Demetry, and Director of Professional Development of the WPI STEM Education Center, Mia Dubosarsky. Finally, we researched and contacted three organizations in Costa Rica: Escuela de Agricultura de la Región Tropical Húmeda (EARTH) University, Gecko Architecture, and Pura Vida Sunsets Eco-Village. These organizations have established sustainable practices in design, material selection, and building operation that expanded our knowledge on possible improvements for CTPSA. Our efforts gave us a better insight into educational and sustainability resources and practices we could introduce to CTPSA.

3.2.1 Evaluation of Educational Practices and Resources

In addition to our visits to CTPSA mentioned in Objective 1, we also wanted to gain perspective from a school with similarities to CTPSA. Mr. Carranza and Ms. Ruiz helped us coordinate a visit to Colegio Técnico Profesional de Educación Comercial y Servicios

(COTEPECOS). COTEPECOS was a valuable school to visit because not only is it well established, but it also has two specialties, Accounting and Executive Services, that CTPSA has. Although COTEPECOS does not have Computer Networking as a specialty, they do have a similar specialty called Software Development. We conducted an interview with Sairis Benavides, an internship coordinator, and Kenneth Salas Arroyo, the principal, and we also toured the school after the interview. The interview allowed us to learn teaching methods, classroom philosophies, and learning resources that were both successful and unsuccessful at COTEPECOS. The interview was semi-structured, so “the interviewers are allowed freedom to digress” (p. 81) and “the interviewers are permitted (in fact, expected) to probe far beyond the answers to their prepared standardized questions” (Berg, 2004, p. 81). While we had a general idea what we needed to know, we let our interviewees at COTEPECOS guide the conversation in a unique direction for their school. Because of this freedom, we learned information about topics that we were not previously aware of and therefore could not include in our questions. The questions we prepared and asked during our interview at COTEPECOS are found in Appendix C. The tour, meanwhile, allowed us to view how COTEPECOS had implemented learning spaces similar to those intended for the KMC. Educating ourselves on successful and unsuccessful innovation attempts at COTEPECOS gave a starting point for assessing CTPSA’s innovation opportunities.

In order to gain a perspective outside of Costa Rica about teaching styles and effective collaborative classroom configuration, we held phone interviews with Ms. Demetry and Ms. Dubosarsky. We originally contacted Ms. Demetry because of her leadership in collaborative teaching and learning at WPI. From this interview we were hoping to learn more about collaborative classrooms from someone who has experience in collaborative teaching styles. Ms. Demetry also referred us to Ms. Dubosarsky due to her experience working with K-12 schools. We intended to get a better perspective of how these teaching methods and classroom setups are implemented specifically for high schools. The questions we prepared and asked during our interviews are found in Appendices D and E. These questions allowed us to guide the discussion and get valuable information on classroom configuration and teaching method considerations.

3.2.2 Sustainability in Costa Rica - EARTH University Visit

In addition to learning about what could be done within the classrooms of the KMC, we also needed to learn about ways to incorporate sustainability into the building. To do this, we

reached out to organizations in Costa Rica with specific focuses in sustainable design and sustainable practices. Of specific interest was EARTH University, a Costa Rican agricultural school with a campus in Guácimo. EARTH University's innovative sustainable efforts helped us discover building design ideas and other sustainable practices that could be beneficial to CTPSA.

We contacted the manager of educational tourism of EARTH University, Diego Hernandez Bermudez, to organize a tour of the EARTH University Guácimo campus. When we visited EARTH University, we spoke to the Environmental Action Program coordinator, Manrique Arguedas, who gave us a presentation on the school's specific sustainability efforts and educational outreach programs. Mr. Arguedas gave us a tour of the recyclables separation plant where we learned about the recycling program at the school and how a similar system could be implemented at CTPSA. We also interviewed Luis Carlos Ruiz, a Special Project Engineer, to learn more about how EARTH University designs buildings to passively benefit from the environment. Base questions for our interview with Mr. Ruiz are found in Appendix F. We then took a tour with Mr. Ruiz to see the implementation of these designs around the campus, where we photographed elements that we felt could be relevant to the KMC.

In addition to our visit to EARTH University, we reached out to other sustainability professionals in Costa Rica and at WPI. We spoke to Oliver von der Weid, owner and architect of Gecko Architecture, to learn about his specialty of incorporating vegetation into architecture and creating cost-effective building solutions. Our questions for Mr. von der Weid are found in Appendix G. Additionally, research into the real estate developer Pura Vida Sunsets Eco-Village yielded specific design components that are beneficial in the tropical climate. Finally, assistant director of sustainability at WPI, Elizabeth Tomaszewski, informed us of sustainability on WPI's campus, focusing on small considerations that could be beneficial to CTPSA.

3.3 Objective 3: Assess appropriate educational and sustainability options in the scope of CTPSA's financial conditions and curricular goals

In order to determine educational resources and sustainability considerations that are valuable to CTPSA, we worked to assess how to fit the implementation of the KMC with CTPSA's finances and curriculum. The biggest issue that we addressed in this objective was how to separate realistic and unrealistic options. To work at making this determination, we briefly studied the condition of the land planned for construction of the KMC, we researched

online some available resources and we performed a simplified analysis of the value of options we decided were viable.

3.3.1 Current Architecture Plans for the KMC

CTPSA is working with Katia Marten Arquitectos for the design aspect of the KMC, and we viewed the presentation by the lead architects, Aldy Solano and Diego Sánchez, to learn what work they have already done for the new building. While talking to the architects, we wanted to learn how developed their decisions were on various design considerations, including materials and layout, and how our work could further the architects' plans. We presented ideas from our visit to EARTH University to Katia Marten Arquitectos so that their future work would incorporate a significant but practical level of sustainability into the KMC's forthcoming designs.

3.3.2 Research for Online Resources

In addition to our visit to COTEPECOS and our interviews with Ms. Demetry and Ms. Dubosarsky as methods of learning about classroom resources, we did extensive online research into free and paid educational resources that could benefit CTPSA. We downloaded certain free online files and software and asked the appropriate teachers to look through the different programs to assess whether they would be valuable for their classes. Presenting our findings to the teachers during our focus group meetings gave us some valuable feedback on the plausibility and utility of what we found. This process was important because CTPSA is interested in accessing the abundance of free online resources.

3.3.3 Value Analysis of Resources

From our observations and interviews in objectives 2 and 3, we were able to identify certain plausible options for CTPSA in terms of sustainable initiatives and educational resources. We proceeded to further investigate these plausible options with the goal of identifying their positive and negative aspects. Specifically, by evaluating the total value associated with a resource option, we hoped to determine how some could be more beneficial than others. The government is interested in keeping costs down, so options that we recommended needed to have a good value for their costs. We interviewed Ida Cortés, the President of the Administrative Board of CTPSA, to learn about the history of the Ministry of Public Education's opinions towards similar expansion projects at CTPSA. In order to report our findings on the value of different resources, we made tables identifying strengths and weaknesses of the options we

found, specifically for building materials and educational resources. We based the strengths and weaknesses on factors such as price, relevance to all students, and ease of implementation. The knowledge presented in these deliverables helped us best present our findings to CTPSA which will give them the best guidance towards implementation of the KMC.

3.4 Objective 4: Develop a comprehensive plan that identifies subsequent steps the school can take to realize their flexible and sustainable learning space

In order for CTPSA to use our research comprehensively, we analyzed our data gathered from the three previous objectives and synthesized it into an applicable report to be used by the school. We began this analysis by looking through our data to find broad topic areas related to improvements that could be made at CTPSA and implemented through the KMC. We then took the broad topics and used a method called coding, which involves filtering mixed interview, focus group, and observational data to find patterns and specific relations to these topic areas (Auerbach & Silverstein, 2003). Coding allowed us to separate the data we collected into specific themes from which we were able to develop findings and make recommendations to CTPSA. Successfully achieving this analysis allowed us to develop a plan for educational and sustainability options to guide CTPSA towards implementation of the KMC.

3.4.1 Format of Results

One of the most important considerations for this objective was to be sure that our results and suggestions were formatted such that CTPSA can use them moving forward. In order to achieve this, we needed to know more about exactly what the school plans to do with our findings after we share them. We decided that creating a catalogue that includes options and characteristics of various resources that we recommended to the school was the most effective way for them to use our research to properly equip the KMC. The best way to determine this information was to meet with administration from the school, specifically Ms. Cortes, to learn about the process of funding and construction. Producing our findings in a way that can be used by CTPSA is vital because the goal of our project is to help the school. Our best opportunity to help them is if the information in our report can be used to advance the project to construction.

3.4.2 Understanding the Process

Before we were able to suggest a plan of action for the school, we had to learn about the process of how schools gain financial support from the government in Costa Rica. Because

CTPSA is a relatively new school, there were numerous staff members at the school with experience in this process who knew this information. We were able to speak with Ms. Cortes who gave us very specific information about gaining government funding. We needed this information so that we knew the status of the project to build the KMC. We also needed that information in order to determine the best way for our group to help advance the project.

3.4.3 Resource Funding and Donations

We attempted to make this project more financially realistic by researching private organizations that work to assist schools by providing them with needed resources. As a starting point for researching funding, we interviewed social entrepreneur and founder of Fundación Paraguaya, Martin Burt. When we interviewed him, we wanted to learn about the availability of outside help for CTPSA and where we should focus our research efforts. Additionally, through speaking with the focus groups of both students and teachers, we were able to identify various resources that the school is going to need to properly equip the new building. Once we identified the needs of CTPSA, we looked to find relevant organizations that may be able to help the school access these different classroom resources. We researched these organizations in order to help ensure that the school is able to get the best use out of their new learning space. Also, if the school is confident with their ability to access resources for the new building, then they will be more likely to begin construction in a timelier manner.

As shown in the four objectives outlined in this chapter, our project was accomplished through thorough investigation, analysis, and reporting. Overall, the first half of the project was spent interviewing and talking to focus groups to gather information, while the second half of the project was spent processing the information to report it to CTPSA. In the following chapters, we will discuss what we learned from our data collection and what we recommend CTPSA does to continue moving forward with the KMC.

Chapter 4: Findings

Colegio Técnico Profesional de Santa Ana (CTPSA) sees the Knowledge Management Center (KMC) as an opportunity to enhance their students' educational experiences. They have put an emphasis on expanding their campus to meet the growing needs of the students. In addition to the KMC, CTPSA plans to add three other buildings to their campus. The plans include a cafeteria, music classroom and office building for teachers and administrators to address needs of the school that the KMC cannot. The KMC is intended to be used by as many teachers and students as possible to enhance the process of teaching and learning at the school.

Currently, the students are achieving at a high level and have the fourth highest standardized test scores in the country. They have also had several students and groups win awards and recognition at the national level in Costa Rica. It is clear when speaking with students and teachers at CTPSA that there is a unique sense of motivation and pride which allows students to set challenging goals and achieve them. The KMC should allow the students to continue dreaming ambitiously while giving them more resources to pursue those dreams.

In this chapter, we give five findings from our research at CTPSA that have direct implications in the process of developing the Knowledge Management Center. The findings synthesize information we learned through focus groups, interviews, direct observations, and additional research in order to make specific recommendations for CTPSA in chapter 5.

Finding 1: Teachers and students at CTPSA are limited by currently available technology and physical resources.

Education at CTPSA is more focused on real world skills and job preparation than education at more traditional, academic high schools. Therefore, it is very important that the teachers prepare the students to be competent and knowledgeable in their respective specialties by the time they graduate. Teachers must be able to closely simulate real world situations and expose students to conditions they are likely to experience in their future professions. Students must also have the ability to take an active role in their education. Although CTPSA's students and teachers currently do this well, they can still improve if they are provided with the appropriate resources. The specific areas that we found need to be addressed are: number of computers, space specifically designed for collaboration, books, and hardware used for learning English. Computer based learning, teamwork, and English fluency are all specific skills that can be improved through these additional resources.

Computer access at CTPSA is not always sufficient to meet the needs of the school. Numerous students and teachers identified that computer labs at CTPSA do not have enough computers for full classes of students. They recognized that requiring students to share computers does not give them as much exposure and experience as they would receive if every student had their own. Although much of CTPSA's classwork is done in groups, students benefit if they are able to each do work on their own computer to contribute to their group. The lack of computers is especially limiting for students in specialties that focus on computer use, specifically Computer Networking. According to Sairis Benavides, the internship coordinator at Colegio Técnico Profesional de Educación Comercial y Servicios (COTEPECOS), Software Development students at their school use computers for around 20 hours per week, and that specialty is very closely related to Computer Networking (S. Benavides, Personal Interview, March 31, 2016). At CTPSA, students were using the computer for the entire 2 hour period in a Computer Networking class that we observed, but most of the students were sharing the laptops being used. In the Accounting class that we observed, students used the computers for the majority of the class while also sharing some of their findings with presentations. Computer use is central to education at CTPSA, and the addition of the multipurpose computer lab in the KMC serves to extend and expand computer availability to improve students' technical abilities and give them opportunities to work together.

Collaboration offers many benefits to students, and having access to space designed to encourage collaboration makes working together more effective. Working in groups is already a widely used strategy at the school. Edwin Montero, an Accounting teacher at CTPSA, estimates that his classes work in groups 80% of the time. The information we gathered from observing classes at CTPSA also supported the idea that group work is frequently used. The two English classes that we sat in on both worked in groups for the entire class while the Accounting and Computer Networking classes participated in a combination of group and individual work. We learned about the lack of classroom space designed specifically for group work from our discussions with student focus groups. Students and teachers agreed that such a space would be important for CTPSA to extend its collaborative methods. The amount of time CTPSA students spend working together is an important consideration when designing new spaces for the school in order to ensure that the layout matches the needs of the school. Collaboration and sharing ideas are essential to the KMC being effectively integrated at CTPSA.

Books are a vital resource for schools, even though many schools are looking to push in the direction of digital reading material. Both students and teachers at CTPSA identified availability of books as an area that can be improved at the school. The school sometimes struggles to provide up-to-date and relevant reading material for their classes, particularly material in English to reinforce reading comprehension. The effect of a lack of physical reading material is amplified in schools that have limited access to online reading material. The cost of these books is the biggest reason that this is an issue at CTPSA. Specialized and advanced textbooks are much more expensive than books intended for general academic subjects. Despite the cost, they are important for the students because it allows them to review sections they missed or did not fully understand from the lessons in class. According to Fabiola Ruiz, a Professional English teacher at CTPSA, books in another language can also help when learning that language. The reduced availability of books in classrooms, particularly those without computers for reading digital materials, limits teachers' options for class activities.

Learning English is a large focus for all students at CTPSA. Becoming bilingual allows students to communicate with thousands of new people and is important for many jobs related to CTPSA's three specialties. Students and teachers involved in the English department wish to obtain two specific resources: headphones with microphones and speakers with the ability to play sound from multiple audio sources. Headphones would allow the students to record themselves speaking and play the audio back to hear and critique themselves. English speaking proficiency and listening comprehension are very important to CTPSA students, and the lack of this audio visual equipment is limiting this very important curricular area. Students' oral exercises are currently recorded using phones and other devices not specialized for audio recording. Speakers are not well-suited for playback from these devices, creating a mismatch in technology and a limitation for students and teachers. The school's capability to improve with the additions mentioned in this section relies heavily upon their ability to properly implement them in their campus.

Finding 2: Using available resources effectively is just as important as having them being state-of-the-art.

The effect of not using resources to their full potential is amplified when resources are already limited, as they are at CTPSA. We observed resources being underutilized at schools due to insufficient need and a lack of properly trained staff. During our visit to COTEPECOS,

Ms. Benavides informed us that their school has a “mobile laboratory” of 20 laptops that is not used often. COTEPECOS has four computer labs with 20 computers each and two classrooms with 5 computers each that are consistently used, but the mobile laboratory is used less often. The mobile laboratory is state-of-the-art because it has the potential to be multifunctional and used in any room, but the money and effort spent setting up this mobile laboratory could have been spent to secure other resources that COTEPECOS needs more. Since CTPSA has a limited budget for the KMC, ineffectively using resources would negatively impact them greater than schools with more money.

Lack of training is another reason that resources are used inefficiently, as state-of-the-art resources often require users to have a more extensive knowledge. Improper training and knowledge wastes potential in educational resources, and efficiency is an essential theme for the KMC. COTEPECOS has an interactive projection board that they are not able to use as anticipated because staff are not properly trained. Similarly, at CTPSA, there are currently no teachers who know how to access and use the accounting software Siscont. The school identified Siscont as a good accounting software, but any money or other effort expended on obtaining the software was a waste since it is now not being used.

CTPSA also shows examples of how it effectively uses certain supplies efficiently even though they would not be considered cutting-edge. In particular, a majority of the workspaces at CTPSA are small student desks that alone are not ideal for group work and collaboration. However, when the desks are put together, they make a pentagonal or hexagonal shape which facilitates conversation and group participation in classes. The desks put together in an English class we observed at CTPSA are seen in Figure 2. The students were able to sit in this kind of formation the entire period which allowed them to work together and help each other in every activity throughout the class. In an interview with social entrepreneur Martin Burt, he stressed that while organizations are looking to expand, they also must assess how they can improve on the use of what they currently have (M. Burt, Personal Interview, February 17, 2016). With CTPSA’s limited budget, their ability to use what they have effectively



Figure 2. Students desks arranged for collaboration in a CTPSA English class

has resulted in successes comparable to schools with better capacity to acquire new materials.

The successes of CTPSA will only be extended through the new resources in the KMC. The KMC will have limited space and a limited budget, and as CTPSA continues to acquire new resources, they will be most successful if they use all resources, state of the art or not, as effectively as possible.

Finding 3: Securing a reliable internet connection at CTPSA is critical to promoting innovation and preventing isolation.

Using the internet is an activity that is essential in innovating learning styles because it allows access to online resource networks and facilitates connections. Faculty and students in our focus groups identified slow and unreliable internet as one of the biggest hindrances that they believe the school faces.

Further investigation into the internet connection speeds revealed the specific issues. Figure 3 and Appendix H show the upload and download speeds of the school's internet connection in megabits per second (Mbps) taken over the span of three hours. The average download speed

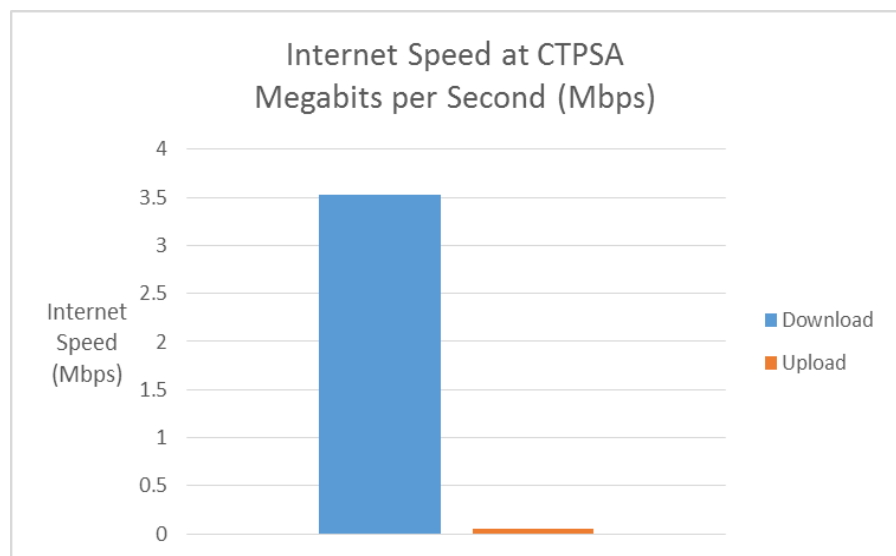


Figure 3. Internet speed data at CTPSA – average values for 16 tests over three hours

of approximately 3.5 Mbps is not excellent but is adequate for basic, non-streaming activities (Burns, 2014). However, the upload speed of approximately 0.05 Mbps is far less speed than CTPSA requires. While more content is downloaded than uploaded, upload speed comparable to download speed is still required to access websites quickly and is important with the increasing popularity of “cloud” storage (“Why is Upload Speed Important?”, 2014). CTPSA is supposed to have a 10 Mbps connection according to their internet provider, but that is not the speed that they are getting for upload or download speeds. A lack of fiber-optic cable infrastructure and the

use of wireless instead of wired connections in classrooms contributes to these problems which affect CTPSA's ability to innovate in their educational practices and make distant connections.

Current efforts at CTPSA to incorporate online resources into their teaching methods are being limited by the internet speed and reliability. We learned that efforts to provide assignments and supplementary documents through the online services Moodle and WebQuest are limited by teachers' inability to upload materials and students' inability to download it. Teachers and administration also expressed interest in accessing online reading materials and software that are available for free. There is potential for CTPSA to incorporate more technology use in the classroom, but internet issues cause student and teacher frustration that interferes with the possibility for innovation.

According to the Teaching and Learning Center at the University of North Carolina Charlotte, a key feature in the new, collaborative classroom is that students must access data from the internet as a fundamental step in the learning process ("Collaborative Learning Spaces", 2016). We learned that students at CTPSA, particularly Accounting students, must frequently do internet research to learn about new topics. Students must connect themselves with new information both in the classroom and in jobs after graduation. The ability to do research on unknown and new topics is central to the practical emphasis of education at CTPSA, and the shortcomings of the internet connection are notably impacting students' ability to do this. Although a variety resources exists on the internet for both students and teachers, inadequate connection to the internet isolates CTPSA from these virtual possibilities.

Feedback from our focus group with teachers revealed that they are consistently looking for ways to improve their teaching methods and innovate in their classrooms. When specifically asked about what the phrase "innovative teaching methods" brought to mind, Mr. Montero said that for him, innovative teaching methods involve using all new technology and material that is available. In the opinion of Teaching and Learning Center Director at Worcester Polytechnic Institute (WPI), Chrysanthe Demetry, the best way to find innovative resources to improve teaching and learning is to search for them online and develop a centralized listing of them that all faculty can access. Ms. Demetry stressed that many organizations, schools and others, have web-based resources to assist with teaching and learning that can be found through simple searches (C. Demetry, Personal Interview, 4/18/2016). These resources include videos and other

large files which are almost impossible to download on CTPSA's current connection, severely limiting any benefit that centralization could have to the school.

Steady internet is important for CTPSA's future plans in the KMC. One of the main intentions for the KMC is to assist in forming connections with organizations beyond CTPSA to allow an exchange of resources and knowledge. Students and teachers in our focus groups expressed interest in collaborating on projects with schools around the world. The benefits of connecting schools and forming alliances are well-documented, allowing a flow of resources and a synergistic creation of knowledge ("Global Schools' Alliance - Benefits", 2015; Hardy, Phillips, & Lawrence, 2003). A study from Queensland, Australia revealed that in many organizations, encompassing both businesses and schools, collaboration has both social and operational benefits which rely on connectedness and engagement of the involved organizations (Keast and Mandell, 2012). Currently, CTPSA maintains a connection with De La Salle High School in Minneapolis, Minnesota. CTPSA and De La Salle established an exchange program in which one student from each school will study abroad. Ms. Ruiz, who was responsible for initiating this connection, communicated her dissatisfaction that due to the internet at CTPSA, she is limited to making voice calls to Minnesota. Ms. Ruiz, along with CTPSA's administration, believe that internet access is limiting a broader coalition between the two schools and other schools in the future.

On a very basic level, internet connection allows CTPSA to contact others and connect through email. However, there are possibilities of connecting with other schools that go beyond simple written connections and require a faster, more reliable internet connection. Collaboration on projects involves a frequent exchange of files for projects that students are working on. Additionally, face to face contact through videoconferencing with collaborators requires an internet connection with both adequate speed and reliability. Distant collaboration is inhibited without a reliable internet connection, which would cause CTPSA to miss out on the benefits that come with connections to other schools.

Finding 4: Multifunctionality in any new space at CTPSA is critical to accommodate a complex set of students' needs.

The idea of multifunctionality is the concept behind the Knowledge Management Center. "A multifunctional space can be described as a true integration of different functions in time and

space” (“Multi-Functional Spaces”, 2016). Multifunctional design is different from compartmentalization for distinct uses. It creates a space that can house a variety of activities.

CTPSA has been working closely with the architecture firm Katia Marten Arquitectos. They have developed a layout for the KMC that will split the space into four sections, as seen in Figure 4. The four sections from right to left include an open deck (1), a computer lab (2), a space for collaboration (3), and bathrooms (4). Because the space for this building is limited to 110 square meters (1,200 square feet), only a small fraction of students will use it at a given time. Within the school, there are seven Accounting classes, six Executive Services classes, and five Computer Networking classes, but the KMC will only be able to accommodate two or three classes total at a given time. Additionally, each specialty will not be using the KMC for the

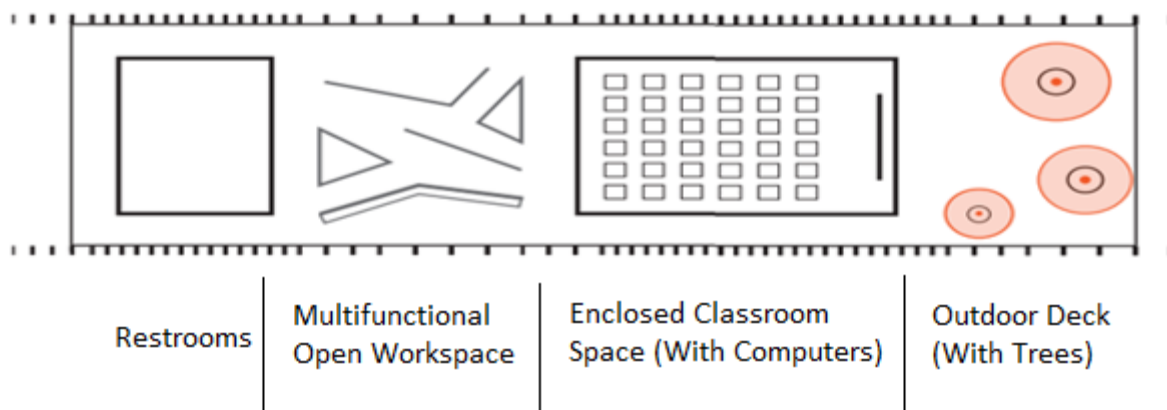


Figure 4. Preliminary design for the KMC
 Property of Katia Marten Arquitectos

same activities. We learned from Executive Services students in our focus group that some days they learn English in their classes while others they will be working on video projects or making posters. Meanwhile, Computer Networking students could be wiring a server or making a new software program on any given day, and Accounting students may need to use Excel software or make presentations to their class. It is important that the KMC is able to benefit all of their students equally even though they will be using the space differently.

According to the Center for Teaching and Learning at the University of North Carolina Charlotte, lightweight, movable and reconfigurable furniture is essential to the ability to change a room quickly and easily. Tables and chairs that are on wheels help to enable easy navigation for reconfiguration during activities (“Collaborative Learning Spaces”, 2016). This concept was reinforced by our interviews with Ms. Demetry and Mia Dubosarsky, the Director of

Professional Development at WPI (C. Demetry, Personal Interview, 4/18/2016). For the spaces to be multifunctional, students and teachers must be able to use their equipment with ease. Ms. Dubosarsky informed us that having accessible and readily available outlets to accommodate equipment that requires power is vital to a flexible environment (M. Dubosarsky, Personal Interview, 4/21/2016). Students at CTPSA have diverse needs in their classes each day, and the school intends for the KMC to be a space that mirrors that diversity.

At COTEPECOS, we observed a multifunctional auditorium space which could be modified to fit different group sizes. As shown in Figure 5, a wooden divider in the middle of the space could divide the larger room into two smaller subsections. Ms. Benavides emphasized it is very useful for COTEPECOS to have the option to use the room as one large auditorium or two smaller ones. This type of functionality is what CTPSA envisions for the KMC and is what students and faculty believe will make the space unique and effective.

Multifunctionality in the KMC will help both students and teachers by accommodating the variety of needs of each specialty while providing students a place to share ideas outside of the classroom that enhance their education.

Finding 5: CTPSA has the unique opportunity to incorporate realistic and functional sustainability considerations into the design and operation of the Knowledge Management Center.

According to Ida Cortés, the president of CTPSA's administrative board, and Sergio Sepulveda, a retired business professional and volunteer with CTPSA, the Ministerio de Educación Pública (MEP) has customarily only approved educational buildings that are simple, square concrete buildings similar to the building in Figure 6. The disadvantage of continually constructing buildings that lack creativity in a school environment is the loss of an opportunity to inspire students to learn and be creative. Jessica Gauci, a teacher at Picton High School, asserts that creating a welcoming and inspiring environment is important because it can positively or

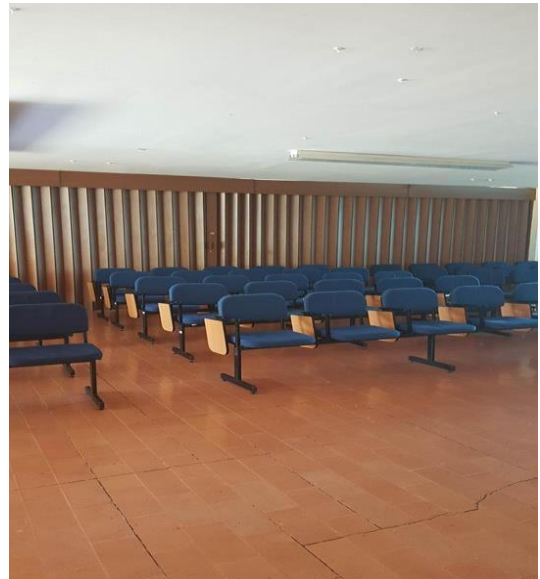


Figure 5. Multifunctional auditorium space with a wooden divider at COTEPECOS

while also conserving resources. The implementation of cross ventilation, natural illumination, and vegetation are sustainable design considerations that are appropriate for the tropical climate.

Cross ventilation significantly decreases the amount of energy used in a building in a tropical climate by decreasing the amount of air conditioning needed. Keeping the KMC at an appropriate temperature is important for creating a comfortable learning space as well as protecting the computers inside. Luis Carlos Ruiz, the Special Projects Engineer of EARTH University, explained to us that long, narrow buildings capture more natural light and wind. Through further research into cross ventilation, we discovered that the Pura Vida Sunsets Eco-Village also encourages cross ventilation in other ways including large windows so that “breezes can blow through from any direction” and ceiling fans that increase air circulation. Fans “not only cool, but they also keep a room dry... which reduces fungus and maintenance” (McCabe, 2016, para. 3-6). Both Mr. Ruiz and Katia Marten Arquitectos recommended having higher ceilings in the building so that heat can rise and cool off within the rooms. By combining large windows, high ceilings, and ceiling fans, a room can cool off faster by circulating cooled air. These basic design considerations are beneficial to both the environment and the building, and are the types of considerations that CTPSA believes should be incorporated into the KMC.



Figure 7. Solar panels powering a classroom at EARTH University

Alternative energy and natural lighting offer more opportunities for buildings to passively benefit from the environment. We learned more about these concepts from Mr. Ruiz at EARTH University. When we took a tour of EARTH University, he told us about using both active and passive solar energy. Active solar design involves the use of photovoltaic (solar) panels. Figure 7 shows a picture of the panels that were used to help power a classroom in EARTH University. Mr. Ruiz also spoke about how the technology of solar panels is advancing and that the amount of energy one can obtain from panels has increased almost tenfold within the last decade. Meanwhile, passive solar design at EARTH University is accomplished with solar tubes also known as solar domes. Solar tubes have the ability to direct sunlight into a building to provide lighting while also deflecting UV rays to prevent heat from entering the building. Figure 8



Figure 8. Passive solar domes (left) contrasted with electric lighting (right) at EARTH University

shows solar tubes that are used on EARTH University’s campus. Solar tube lighting is on the left of the picture, while electric lighting is on the right. It is worth noting that these solar domes appear as bright as the electric lights. Using the sun’s energy and light effectively is a design consideration that can easily reduce an electric bill and a building’s impact on the environment.

Even with the use of natural illumination, there will be times where additional lighting is needed. Mr. Ruiz and Elizabeth Tomaszewski, Associate Director of Sustainability at WPI, encouraged the use of LED lighting. Despite the initial investment, their long life, high efficiency, lack of maintenance, and small amount of emissions make this type of lighting a more cost-effective and eco-friendly choice compared to incandescent lights (“LEDBenchmark - Pros and Cons of LED Lighting,” 2016).

The concept of incorporating vegetation into building design is used within the building plans of Katia Marten Arquitecto for the KMC. We learned more about this topic from Oliver von der Weid, an architect of Gecko Architecture who specializes such considerations. When we spoke to CTPSA about using vegetation for shade on their land, Mr. Sepulveda expressed concern that their current trees lose their leaves and are not able to provide shade for their students. However, Mr. von der Weid recommended both citrus and ficus trees as examples of trees that keep their leaves all year. Trees have been shown to reduce “wall surface temperatures by up to 9°C” (Berry, Livesley, Aye, 2013). Such trees can be seen in Figure 9, a shaded eating space for



Figure 9. Naturally shaded lunch area at COTEPECOS

students at COTEPECOS. The trees present at COTEPECOS did not lose their leaves and provide adequate shade for the students. Their trees serve as a low-cost place for students to eat and relax. The functional sustainability considerations that we learned about present the possibility of saving money as well as actively participating in environmental efforts.

Having a full knowledge of conditions at CTPSA and specific options that exist that are relevant to CTPSA now allows us to move towards making specific recommendations for the school as it continues to plan for the KMC. The following chapter lays out different options that the school can take in planning and utilizing the KMC. Our recommendations aim to provide a broad array of knowledge for CTPSA and also allow future work to be done eventually leading to the successful materialization of the KMC.

Limitations

Despite all of the opportunities that we have been given to do research and speak with experienced professionals, there are still some limitations on the data we collected. One specific limitation was that the only group of students we were able to speak with extensively were in 11th grade. Speaking to students in 10th and 12th grade could have given a more in depth knowledge of the student experience at CTPSA. Additionally, we spoke with five different teachers, two members of the administration, one member of the judicial board, and a volunteer. Speaking with as many teachers as possible could have given us a slightly broader perspective of the school. Finally, we were only able to visit one other technical high school in Costa Rica (COTEPECOS), where visiting more could have given us a more complete perspective on what other schools are doing and how they fit with what CTPSA wants to do. Specifically, at COTEPECOS we observed distinct differences from CTPSA due to differences in location and age of the schools. Seeing how these differences affected other schools would have broadened the scope of our data. In spite of these limitations, we feel that the research we did is sufficient to make recommendations that are in CTPSA's best interest moving forward. Our findings serve as a base for chapter five where we make specific recommendations for CTPSA which aim to guide them in successful implementation of the KMC.

Chapter 5: Recommendations

The specific and unique needs of Colegio Técnico Profesional de Santa Ana (CTPSA) require a particular set of resources and an appropriate building design. Even once the resources and design fulfill the requirements of the school, it is still necessary to effectively implement these new components into the standard operation present at CTPSA. In the following chapter we share our recommendations regarding how to properly design and equip the Knowledge Management Center (KMC) as well as how to effectively use the resources and building to strengthen the students' educational experiences. Appendix I lays out a more comprehensive plan and framework for the Knowledge Management Center, expanding on each recommendation presented in this chapter.

5.1 Internet Connectivity

Improving their internet connection is central to CTPSA's current education and future goals in the KMC. We offer three specific methods which CTPSA should pursue to improve their internet for both short term and long term use.

CTPSA's ability to establish video contact with other schools is limited by their internet's upload speed, as identified in Finding 3. Even with adequate speed, maintaining constant video contact through videoconferencing software such as Skype requires a reliable connection. To achieve this, CTPSA should test a USB internet connection provided through the company Claro, called Internet Móvil. The speed of the prepaid Internet Móvil is listed as 2 Mbps, which would provide more than enough download and upload speed for a single user and drastically improves on CTPSA's current upload speed ("Internet Móvil", 2016). According to the third party internet speed website OpenSignal.com, the average download and upload speed for Claro in Costa Rica are above what Skype recommends for videoconferencing ("Claro mapas de cobertura - Costa Rica," 2016; Kingswood, 2013). Although our rough testing indicated that there is adequate data coverage at CTPSA, the school should investigate further before fully implementing a data stick so that money is not wasted on an inadequate connection.

Our other internet recommendations address the internet infrastructure present at CTPSA. Currently, the school does not have fiber optic cables to transfer internet data from the street to the classrooms. Fiber optic cables are much faster than traditional copper cables and would allow CTPSA to better access the full 10 Mbps that it is paying for from the internet provider. The

cables must be installed by hired professionals to work properly, but it would be a worthwhile investment because it is a one-time action that would improve the internet for the entire school. Having fiber optic cables is important because the maximum internet bandwidth is likely limited by the improving national infrastructure of Costa Rica, and CTPSA needs to take advantage of all it has available (Agüero, 2016). While getting money to install and implement fiber optic cabling will take time, we recommend using wired internet connections instead of wireless connections to speed up the internet. Wireless internet is advancing, but there are still speed advantages to having a physically connected computer (Yin, 2011; Smith, 2013). Many of the classrooms at CTPSA already have Ethernet ports in the classrooms, and the KMC must be built with enough, if not more, ports than computers that will be in the building. Ethernet provides a more immediate improvement to the internet than installing fiber optic infrastructure, but both are steps that CTPSA should take to maximize on the internet they have.

5.2 Backup Power

CTPSA would benefit from having a backup power source in case of power outages. This is something that currently interrupts learning and would affect the school even more when the KMC is built due to the amount of technology that will be in it. Therefore, adding an emergency power system to the campus would help the school before the KMC is built, and it would also make the building itself more useful to the school. Diesel and gasoline powered generators are the most affordable options in terms of initial cost, and propane powered generators offer more benefits environmentally. The most environmentally conscious option for backup power would be a solar powered battery backup system, but such a system would be financially unrealistic for CTPSA to install and maintain. The best option for CTPSA is the diesel or gasoline powered generators due to their lower cost. Because a generator would only be used during outages to supply power to necessary areas of the school, the environmental impact would be limited from the fuel powered generators. Additional information on other alternatives for backup power systems can be found in Appendix I.2. Power outages at CTPSA occur often enough to be considered a problem by teachers, and the problem will be even greater with the increased level of technology that is proposed for the KMC. Having a generator would solve these problems and allow the KMC to be used to its fullest potential.

5.3 Classroom Setup and Resources

We recommend that when CTPSA selects furniture and a classroom set up for the Knowledge Management Center, they focus on multifunctionality. Tables and chairs must be light and mobile to support rearranging classrooms quickly and easily. In order to do this, chairs should be able to roll to allow students to move around easily in a work setting. Similarly, tables must be on wheels or sliders that allow them to be rearranged easily by one person. The wheels on the tables must lock, however, so that once in place the tables provide a stationary place for students to work. While the furniture should be lightweight, CTPSA must also make sure it is well made. Some lightweight furniture will fall apart and break after only a few years, so material is not a trivial consideration. In particular, we recommend metal instead of plastic or wood because it combines both durable and lightweight characteristics. One more important group of resources that we recommend for CTPSA to have in the Knowledge Management Center is whiteboards and corkboards. Whiteboards that can be carried or rolled around the rooms in the KMC would be critical to the collaborative work that will be done there. Additionally, corkboards and other surfaces to hang decorations, class materials, and student work are critical additions to make the space in the KMC appealing to students and helpful to their work. Further considerations for classroom setup are found in Appendix I.4

5.3.1 Photocopier

Students and teachers cannot easily copy and print work at CTPSA. Providing teaching materials and sharing student work are important aspects of education, and supplying proper copying and printing capabilities would make these things much more accessible at the school. Regarding student use, our group found out from talking with student focus groups that Executive Service students need the most access to a photocopier. Additionally, we found that students would be willing to participate in efforts to raise funds for the school to access necessary resources. A fundraising event held by the Executive Service students would be a useful way to make the photocopier a realistic option for the school. Specific information on the type of copier and our recommend implementation is found in Appendix I.3.

5.3.2 Power and Ethernet

A consideration that goes along with the design of a multifunctional classroom space to incorporate technology is the placement of power outlets and Ethernet ports. We recommend that these connections are not only plentiful on the perimeter of the rooms in the KMC but also

that they are built into the floor. A central idea to the multifunctionality of the tables and chairs is that if needed, the space can be completely opened up. However, if there is any physical framework for power outlets or Ethernet ports in the inner space of a room, it will interfere with a room being truly open. If the infrastructure is built into the floor, it will be available when needed and hidden when not. The KMC will house a large array of technology, so we recommend that CTPSA fully considers everything that is in need of a power outlet including computers, speakers, recording equipment, and even students' phone chargers.

5.3.3 Computers

The curriculum at CTPSA requires that the students have advanced computer skills, and many of the activities at the school require use of computers. This is a very expensive need that has left many classes struggling to provide sufficient computer accessibility to all students. It is therefore important to have at least one space in the school to which every class has access that can give every student in the class an equal opportunity to advance their education using the computer. The KMC should have enough computers to accommodate any class size at the school, the largest being 25. Having full access to the computer for the entire lesson would prepare students better than spending part of the class watching a classmate use the computer.

As mentioned, acquiring enough computers for every student in a class is a large expense, but there are ways to address that issue. More specifically, there are organizations that have donated computers to schools in need that CTPSA could contact to help them properly equip the KMC. Four organizations that may be willing to help CTPSA access these computers would be Amigos of Costa Rica, Kramden Institute, the Reader to Reader organization, and Global Digital Divide, and these companies can be seen in Figure 10. A more in-depth description of each company can be found in Appendix I.5. It would be important to convey to these organizations how these computers would be used to enrich the education of hundreds of motivated students. This way, the organizations can be confident in knowing that their donation will be used effectively and will have a positive impact on hundreds and eventually thousands of students.



Figure 10. Organizations that can help CTPSA access new computers

5.3.4 Software

As mentioned in Finding 2, it is important for CTPSA to use its resources effectively. Because of this, we recommend that they build up their collection of software so that computers are used most effectively. Currently, CTPSA computers use Microsoft Windows operating systems, which cost a significant amount. However, there are free operating systems that exist that can run almost any program that a Windows operating system can. In particular, Ubuntu is a Linux based free operating system that has many available resources to teach students how to use it. Other free operating systems exist, but Ubuntu is the most common (“Developer Survey 2016 Results,” 2016). Microsoft Windows operating systems come with Microsoft Office programs like Excel and Word, and these programs are central to the technical work in all three specialties. However, we recommend that CTPSA investigate the free equivalent of Microsoft Office called Apache OpenOffice which has almost the same functionality. While many companies specifically look for skills in the Microsoft Office Programs, the OpenOffice programs operate in almost an identical manner, so CTPSA must maintain a balance between using free software and training their students for the use of specific software in their future jobs.

We recommend that CTPSA continues to search online for free software, as new software is being developed and improved constantly. If CTPSA finds a software program that can be implemented even for one unit of one class, it would benefit students. An example of this is the free program GnuCash, a relatively simple accounting software. This software would be effective in some early Accounting units, and while it would not be extremely useful in later units and therefore not interfere with Accounting-specific job software, it still would benefit all Accounting students. Even if CTPSA can gain slightly from each free piece of software it finds, those gains can be significant with the rate at which software is developed and made available online.

5.3.5 Headphones and Speakers

The KMC has the potential to be an important asset in teaching English to the students at CTPSA. In order for this to happen, the computer lab must be equipped with headphones that have microphones as well as speakers that are connected to a computer. Connecting the speakers to the computer would give English teachers the ability to play audio files on their phones or computers through the speakers, which is something that is currently unavailable to them. This is important because the teachers would gain access to the abundance of free audio files available

online that help students learn English. The headphones with microphones would allow the students to record themselves speaking English and then play the audio again to review themselves. It would also give teachers the ability to give students speaking assignments and oral exams by having the students record themselves so that the teacher can listen to it as many times as they need to give a proper assessment. These resources would be very helpful to the language learning department at the school and the KMC is a perfect place to put them so that everyone can access them.

5.3.6 Books

We recommend that CTPSA reaches out to both local and international organizations that donate books to schools. Book donations are crucial for CTPSA because their limited budget prevents them from being able to purchase quality books for their students. Since it is a public institution, they cannot require the students to purchase their own books. Textbooks and books to read for pleasure are very important for the education of the students, so giving them access to these resources is essential. When searching for organizations for book donations, there are several promising options available which we expand in Appendix I.8. It is important to note that the local organizations should be reached out to first because they are more inclined to respond and help in a timely manner.

5.4 Teaching Methods

The best way to ensure that newly acquired resources are being used to their fullest potential is to evaluate which teaching methods make best use of the available materials. The two main spaces in the KMC that are going to be used by teachers are the computer lab and the dynamic, flexible learning space. Therefore, it is vital that these spaces are being used to incorporate innovative teaching methods into the curriculum as opposed to using these spaces simply as a change of environment. The computer lab that is planned for the KMC gives the opportunity for every student to use a computer, a luxury that is not present in almost any classroom currently at CTPSA. Accordingly, it is important that this lab be used by as many classes as possible, and it should be used for the sole purpose of enhancing the student's education with computer skills. The flexible space that is planned gives an entirely different opportunity to classes. It would allow the students and teachers to configure the room easily to meet the exact needs of their current activity. The emphasis in this space should be to give the students projects and assignments that encourage the students to communicate and learn from

each other, with the teacher's role simply being support and encouragement. An example of a proper use of this space is to have the students use it to brainstorm ideas for a project. This way they would be able to collaborate with each other using the configuration of the room as well as other materials like whiteboards to organize their thoughts.

The same way students can use the KMC to learn from each other, teachers also have the opportunity to do the same using the new building. The best way to do this is to implement a system in which the teachers meet to share and evaluate the ways they have been using the KMC. This building is an exciting opportunity for teachers but many will not have experience with such a dynamic and innovative space. The building is most likely to be used effectively and to its fullest potential if the teachers are able to learn from each other and evaluate the best uses of the spaces in the KMC.

5.5 Networking Opportunities, Connections, and Alliances

As CTPSA seeks to expand their campus, they also seek to expand their connections and communications. Through our research, we found several organizations that CTPSA should look into as a means of improving their international partnerships. To help CTPSA expand their network, we recommend they start with larger networking organizations. Appendix I.9 describes organizations that we believe would be beneficial for CTPSA to reach out to.

5.5.1 Websites and Social Media

An improvement related to these connections that we recommend CTPSA make involves improving their website. In the beginning of this project, we had to access the website to begin learning about the school. It took a long time to find, the content was almost a year old, and much of it was only basic information. CTPSA should re-think the purpose of their website both as a method to communicate their achievements to the world and as a main resource for initiating connections with distant organizations. Frequently updated pages to display student recognition in national competitions as well as more pictures of the frequent events at the school would allow website visitors worldwide to view CTPSA as a unique school. Meanwhile, a variety of easily found contact information including email, phone, and even Skype allow potential collaborators with CTPSA a variety of ways to contact the school, making connections easier to develop.

While improving the website has the potential to improve what people can learn from viewing it, that effort is wasted if nobody can find the website. In particular, Google recommends steps that can be taken to increase how often a website will appear on a relevant

search ("Webmaster Guidelines," 2016). CTPSA should also go a step further in its internet exposure and develop social media pages, specifically including well-updated Facebook and Twitter pages. Facebook and Twitter provide excellent platforms to share photos and updates of everyday activities at schools, and these platforms are continuing to grow to reach more people worldwide. Further suggestions for maintaining these platforms are found in Appendix I.9.

One last platform that we see as beneficial to CTPSA is LinkedIn. This is a platform more aimed at professional connections, which offer potential to students at CTPSA who are looking to join the professional workforce immediately after graduation. Susan Adams of Forbes strongly recommends that high school students get involved in LinkedIn for reasons that include highlighting their achievements and making connections (Adams, 2016). When we were contacting many of our interviewees, we utilized their personal LinkedIn pages, and Costa Rica is providing significant mobile usage of LinkedIn as it continues to grow, so we believe students should establish LinkedIn profiles (Wagner, 2014).

5.6 Building Design

Katia Marten Arquitectos has incorporated many sustainability concepts into their design of the KMC, such as taking advantage of natural illumination and cross ventilation, as mentioned in Finding 5. With these concepts as the foundation to our vision of the KMC, we were able to find more ways that the KMC can be built to conserve resources and save money through efficiency.

5.6.1 Illumination

The use of photovoltaic (solar) panels is a promising alternative energy source that should be looked into for the KMC. Even though initial investment into this resource can vary, panels can be designed with different efficiencies to produce a return on investment. The energy that photovoltaic panels produce can be used to run a building. CTPSA should take advantage of this renewable energy source to decrease their electricity bill. There are several companies in Costa Rica, such as Costa Rica Solar Solutions, IntiTech Solar and Solar Costa Rica that are willing to give consultations and install photovoltaic panels, with more information found in Appendix I.10. It is worth noting that while installing a solar battery backup system for short-term backup power is not financially realistic, a battery backup system to compliment solar panels on the KMC would be beneficial during power outages.

Light-emitting diode (LED) lighting in the KMC provides a low-energy alternative for CTPSA. Because of LED lighting's higher efficiency compared to incandescent and compact fluorescent lighting, it should be implemented in the KMC. The disadvantage of LED lighting is initial investment cost, but prices have been declining every year ("LEDBenchmark - Pros and Cons of LED lighting," 2016). Appendix I.11 gives additional information about LED lighting for the KMC. Additionally, because solar tubes can decrease the amount of electricity that is used in a building by providing light and deflecting UV rays, solar tubes should be implemented into the KMC.

5.6.2 CTPSA and Katia Marten Arquitectos

Katia Marten Arquitectos incorporates sustainable considerations such as vegetation, cross ventilation, appropriate and available material choice for the climate, and natural illumination into their building design. Since they are working for free through social commitment, we highly recommend that CTPSA continues working with Katia Marten Arquitectos for both the KMC and other development projects. As CTPSA works with Katia Marten Arquitectos, they should also look to include sustainability considerations that we have identified that are not currently present in the preliminary designs. This will help to further reduce the environmental impact of the KMC while also helping its functionality.

5.7 Recycling

We highly recommend that CTPSA reaches out to EARTH University, specifically Manrique Arguedas, the coordinator of the environmental action program, to establish a connection between CTPSA and EARTH University that would benefit CTPSA's recycling efforts. Students at CTPSA do not always recycle/separate correctly, and properly separated recycled materials can be sold for money and decrease the amount of waste in landfills. EARTH University facilitates programs to train schools in proper recycling practices and to instill an environmentally responsible mindset in students. In addition to collaboration with EARTH University, CTPSA should hold an annual orientation for all students on the importance and process of recycling properly. This orientation would fit well with an annual fashion runway event at CTPSA that only uses recycled materials. In order to encourage better recycling practices, CTPSA should place trash bins next to recycling bins. Students identified that one reason they do not always recycle properly is due to the distance between recycling bins and

trash bins. Increased recycling efforts at CTPSA would extend their sustainable effort beyond the design of the KMC.

5.8 Conclusion

“School improvement is a process, not an event. It takes place over an extended period of time, usually several years” (Van Velzen, 1985, p. 59). As Colegio Técnico Profesional de Santa Ana continues to grow, the school seeks to have a building that can further strengthen their young professionals’ practical technical capabilities. They wish to achieve it through a multifunctional learning space that incorporates local and distant collaboration to improve problem solving skills that will be known as the Knowledge Management Center. Our work is intended to serve as a solid foundation that CTPSA can build off of to continue to develop the idea of the KMC.

We are confident that future work by the school will extend our research and recommendations and that CTPSA will accomplish its goal of implementing the KMC to strengthen its students’ education with practical, appropriate, and sustainable technology. Many of our specific recommendations are short-term improvements that the school can make that are vital to the success of the KMC, and these are as important as our long-term recommendations. Taking our recommendations to continue progress on the KMC will be important as CTPSA secures funding from the Ministerio de Educación Pública. With this funding and support, the KMC will become a reality to connect and inspire students and to set an example for innovative educational development in Costa Rica.

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Appendix A: Questions for Student Focus Group at CTPSA

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with focus groups of Colegio Técnico Profesional de Santa Ana students to learn more about their experiences and opinions about the resources at the school. Our ultimate goal is to determine the best use of a Knowledge Management Center and your insights will be extremely useful.

Your participation in this interview is completely voluntary and you may withdraw at any time. Your identities will be kept anonymous and will be used when we are considering the best course of action for Knowledge Management Center.

Your participation is greatly appreciated.

1. What current resources do you believe help you learn the best?
 - a. How do the following fit into your current education?
 - i. Computers?
 - ii. Textbooks?
 - iii. Internet?
 - iv. Library?
 - v. Teachers and Group work?
2. What comes to mind when we talk about having a library on campus?
 - a. If there was a library, what resources would you want to have access to?
 - i. How would it change how you work or study?
 - b. Would you go there outside of school hours to study or do work?
3. What do you think a new building can be used for?
 - a. *We looked for answers both based on specialty and overall.*
4. Describe one thing you would want to add to the school.
5. Do you notice the school making environmental initiatives (such as recycling)?
 - a. Do these initiatives involve all students?
 - b. Do you think the school could add any specific sustainable initiatives to further its sustainable effort?
6. Are you familiar with other high schools in Costa Rica (through friends, previous experiences, etc.)?
 - a. What about those other schools is different than CTPSA (better or not)?

Appendix B: Questions for Teacher Focus Group at CTPSA

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with Colegio Técnico Profesional de Santa Ana faculty to learn more about their experiences and opinions about the resources at the school and identify possible improvements that could be made to those resources. Our ultimate goal is to determine the best use for a Knowledge Management Center on your campus and your insights will be extremely useful.

Your participation in this interview is completely voluntary and you may withdraw at any time. If you would like, we would be happy to include your comments as anonymous, though it would be useful for readers to understand the basis for certain comments and ideas.

If interested, a copy of our results can be provided at the conclusion of the study. Your participation is greatly appreciated.

1. What subject(s) do you teach?
2. Generally, how engaged are students in the classroom?
3. Do the students work in groups?
4. Would you know how to use ... effectively in the classroom?
 - a. New Software
 - b. New teaching methods
 - i. *New software and teaching methods came from our research*
5. Would you be open to using ... in the classroom? / incorporating it into the curriculum?
 - a. New Software
 - b. New teaching methods
 - i. *New software and teaching methods came from our research*
6. Do you feel that the school is able to provide adequate teaching resources?
 - a. How often does the school get new resources for your classes?
 - i. Differentiate between Major vs. Minor Resources (e.g. Computers vs. Pencils)
7. Do you think the school uses its resources well?
 - a. Do you have any specific ways that the school could improve how it uses its resources?
8. What comes to mind when you hear about *innovative teaching methods*, and what do you think they can offer?
 - a. How do you think CTPSA could use them effectively?

Appendix C: Interview Questions for COTEPECOS Administration

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with teachers and administration at schools in Costa Rica to learn more about their experiences and opinions about the resources at schools and to identify possible improvements that could be made to those resources. Our ultimate goal is to determine the best use for a Knowledge Management Center on the campus of Colegio Técnico Profesional de Santa Ana and your insights will be extremely useful.

Your participation in this interview is completely voluntary and you may withdraw at any time. If you would like, we would be happy to include your comments as anonymous, though it would be useful for readers to understand the basis for certain comments and ideas as coming from a particular person.

Your participation is greatly appreciated.

1. How many students are in your school?
2. When was the school founded?
3. What are some new things your school has?
 - a. New resources?
 - b. New programs?
 - c. New activities?
4. Are there ideas or resources that you have used that have not worked as well as expected?
5. Is there a space that is multifunctional or easily changed?
6. How good is the internet connection?
 - a. Do you know why it is good or bad?
 - b. How might you improve it, if it is bad?
7. How many computers does your school have?
 - a. What percentage of the time do students work on computers?
8. Do your students learn English?
 - a. Is there any sort of language lab?

Appendix D: Interview Questions for Crysanthé Demetry

We are a project group in Costa Rica, and we are working with a technical high school here to help them develop a “Knowledge Management Center” on their campus. We have been looking into a number of areas, including sustainability, educational resources, and teaching methods. We would like to get input from you both as a professor and as the director of the Morgan Teaching and Learning Center at WPI. Our questions mainly concern how to bring innovative teaching methods into the classroom, what resources are particularly useful to involve students, and how teaching methods can be optimized even with limited resources.

We greatly appreciate your input.

1. How did material science lead you to get involved in the Teaching and Learning Center?
2. The students at the school get an academic education and gain a specialized degree. The three specialties at the school are computer networking, accounting, and executive services. One of the main philosophies we have seen at the school in our observations and conversations with students and teachers has been collaborative learning. The ideas of collaboration and group work seem to be very important in your classes, so can you tell us a little more about the specific ways you encourage collaboration in your classes?
 - a. What size groups work the best for you and why?
3. How would an ideal classroom be setup to foster collaboration in your classes?
 - a. What resources would you consider to be most important
 - i. Tables?
 - ii. Chairs?
 - iii. Whiteboards/Chalkboards?
 - iv. Academic Technology?
4. What changes do you have to make to your teaching style when the classroom space is not ideal?
5. How have you seen more student-centered classes differ from traditional classroom philosophy in terms of student understanding, achievement, and motivation?
 - a. Have you found students to be resistant to doing extra work outside of class?
 - b. What do you think has made this classroom setup successful or unsuccessful?
6. What sorts of resources does the Morgan Teaching and Learning Center offer to WPI professors and teaching assistants?
 - a. Are these resources utilized often by the teaching community?
 - b. Is there anything that a school like the one we are working with (~400 students, ~25 teachers) could do to establish a similar teaching and learning resources base?
7. The school is interested in reaching out to other organizations and schools to form alliances of resources and to foster collaboration. What do you feel is the best way for schools to initiate those kinds of connections?
8. The school has limited money and is looking for outside organizations and donation sources. Do you know of organizations that look to donate resources to schools, potentially worldwide organizations?

Appendix E: Interview Questions for Mia Dubosarsky

We are an IQP group in Costa Rica working with a public technical high school who needs our help designing and planning a new building that will be known as the Knowledge Management Center. It is meant to be a building with a few rooms and spaces to encourage collaboration and innovation. We are also going to suggest possible teaching methods so that they can best use this new building. We were referred to you by Chrysanthe Demetry and would like to ask you some questions specifically regarding implementation of collaborative teaching styles in high schools.

We greatly appreciate your help.

1. How would an ideal classroom be setup to foster collaboration in classes?
 - a. How would collaboration in a STEM-type classroom differ from that in a strictly academic classroom?
2. What resources would you consider to be most important to help encourage collaboration? (tables, chairs, whiteboards, technology, etc.)
 - a. Have you found that any resources or teaching strategies in a classroom were not as helpful as you thought they would be? (programs, students working in large/small groups, etc.)
3. What changes must be made to teaching styles when the classroom space is not set up ideally?
4. The school we are working with is interested in reaching out to other organizations and schools to form alliances of resources and to foster collaboration. What do you feel is the best way for schools to initiate those kinds of connections?
 - a. What ways do you know of that make connections between schools beneficial for both schools involved?

Appendix F: Interview Questions for Luis Carlos Ruiz at EARTH University

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with professionals from different organizations to learn more about their experiences in creating and running sustainable buildings. Our ultimate goal is to determine appropriate and effective sustainable practices for our sponsor and your insights will be extremely useful.

Your participation in this interview is completely voluntary and you may withdraw at any time. If you would like, we would be happy to keep your comments confidential, though it would be useful for readers to understand the validity of our sources.

Your participation is greatly appreciated.

1. Do you use clean/renewable energy, including solar, wind, hydroelectric, geothermal, etc.?
 - a. Is it cost-effective?
2. What are the main challenges with trying to balance the need for sustainability with a limited budget?
 - a. What has been particularly cost-effective?
3. We have learned that Costa Rica as a whole has a commitment to sustainability. Do you see evidence of this commitment in areas surrounding your organization?
 - a. Do you collaborate with the surrounding community in a sustainable way?
4. In your building, what materials are used that are particularly green or environmentally friendly?
5. Are there any small things that have a particularly positive effect on sustainability?
 - a. Operation of buildings
 - b. Construction
 - c. Materials
 - i. *Particularly those that may be less obvious*
6. What opposition and difficulty do you find that arises in relation to sustainability?
7. Are there any sustainable initiatives you have encountered (in your organization or otherwise) that you feel are particularly unique?
8. What kind of building materials are the best for this type of climate in Limón
9. How do you incorporate ventilation into construction of sustainable buildings?
10. Could you tell us more about the bio-digester being used on your campus?

Appendix G: Interview Questions for Oliver von der Weid

We are a group of students of Worcester Polytechnic Institute (WPI) studying various areas of engineering who are conducting a seven week project in Costa Rica. The goal of our project is to help our sponsor, Colegio Tecnico Profesional de Santa Ana, expand and build a new “Knowledge Management Center.” This new building will serve as a modern library and give them space for collaboration both in the school and overseas. Additionally, our sponsor wants this new building to be constructed and operated as sustainable as possible.

We believe that your expertise in alternative and eco-friendly designs can help enrich this project. We greatly appreciate your help.

1. One of the key issues for our project is assessing the best suited materials for roof and wall insulation in order to cut off the sun heat with natural low cost materials. Can you tell us more about your experience with that area?
2. What experience do you have designing buildings to include energy efficiency, natural illumination, and natural air flow as part of a cooling system? We want to learn about sustainable initiatives that can be low cost and have a meaningful impact to energy use.
3. We would also like to incorporate plants into the area around this new building. However, Santa Ana has a significant dry season. How can we incorporate plants into building design when the area is very dry, and what plants would be best to do so at a low cost?
4. Are there certain organizations will fund a project like ours because it is sustainable? The school does not have unlimited money at its disposal, and we are looking for alternative organizations that would potentially donate to the project.

Appendix H: Numerical Internet Speed Data from CTPSA

The table shown below represents internet speed data that was taken over the span of three hours.

Internet Speed at CTPSA		
Megabits per second (Mbps)		
Test Number	Download	Upload
1	3.89	0.02
2	2.04	0.08
3	5.63	0.04
4	4.64	0.06
5	6.76	0.05
6	4.31	0.08
7	4.6	0.12
8	1.37	0.06
9	1.24	0.04
10	0.7	0.02
11	2.82	0.08
12	6.36	0.04
13	6.02	0
14	4.11	0.07
15	1.8	0.03
16	0.15	0.02
Average	3.5275	0.050625

Appendix I: Detailed Short-term and Long-term Framework for Successful Implementation of the Knowledge Management Center

In this Appendix, we present a detailed and comprehensive plan of the steps that CTPSA can take in the short-term and long-term to properly and successfully implement the KMC. The table below identifies whether each consideration is more relevant in the short-term or the long-term and the corresponding section of the Appendix goes into further depth about specific considerations related to a particular area. The various sections provide many links for individuals at CTPSA who will continue research and work on the KMC project after we leave Costa Rica.

I.1 Internet Improvement Options	Short-Term and Long-Term
I.2 Backup Power – Generator Options	Short-Term
I.3 Photocopier Options	Short-Term
I.4 Furniture and Classroom Setup Recommendations	Long-Term
I.5 Computer Donation Organizations	Short-Term and Long-Term
I.6 Free Software for Implementation	Short-Term and Long-Term
I.7 Audio and Recording Equipment for English Learning	Short-Term and Long-Term
I.8 Book Donation Organizations	Short-Term
I.9 Networking Opportunities, Connections, and Alliances	Short-Term and Long-Term
I.10 Selecting and Implementing Solar Panels for the KMC	Long-Term
I.11 LED Lighting Opportunities in Costa Rica	Long-Term
I.12 Material Selections and Considerations for the KMC	Long-Term

I.1 Internet Improvement Options

Option		Use	Advantages	Disadvantages
Internet Data Stick (Claro)	Prepaid	Can be used for situations which need a reliable internet connection for one person (e.g. video calls)	<ul style="list-style-type: none"> • Single user - won't be saturated by too many users • Can only be paid for when needed 	<ul style="list-style-type: none"> • Flat data speed (2Mbps) no matter what plan is bought
	Postpaid (subscription)		<ul style="list-style-type: none"> • Single user - won't be saturated by too many users • Can get a faster maximum speed than prepaid service 	<ul style="list-style-type: none"> • Requires a monthly subscription - more money paid gives more speed (from 0.5Mbps - 5Mbps)
Fiber Optic Cable Infrastructure		Increases the internet speed for the school	<ul style="list-style-type: none"> • One time improvement - once installed it will benefit the entire school • Fiber optic speeds will exceed bandwidth allowing for maximum use of available internet 	<ul style="list-style-type: none"> • Replacing all cables at CTPSA could be expensive • Existing cable infrastructure might be difficult to access and replace.
Ethernet Cables to Wire in Computers in Classrooms		Connect computers in classrooms to the internet using ethernet cables instead of wireless connections	<ul style="list-style-type: none"> • Ethernet ports already exist in many classrooms. • Ethernet cables are either as fast or faster than wireless connections • Less potential for wireless interference 	<ul style="list-style-type: none"> • Would have to buy ethernet cables for each computer • May not have enough ethernet ports in each room

The physical USB internet data stick, costs between \$20 and \$30 (¢10000 - ¢15000). Activating the internet using the data stick only on days when you need it will cost slightly over \$1 (¢700) per day that you choose to use the internet.

Ethernet cords are relatively inexpensive (less than \$10 (¢5000) per cable), and buying in bulk may reduce the price even more.

I.2 Backup Power - Generator Options

The following table rates different generator types based on the fuel that powers them. The various attributes are rated as either Poor, Medium, Excellent or Varies. The information from this table was retrieved from generatorjoe.net.

Attributes by Fuel Types

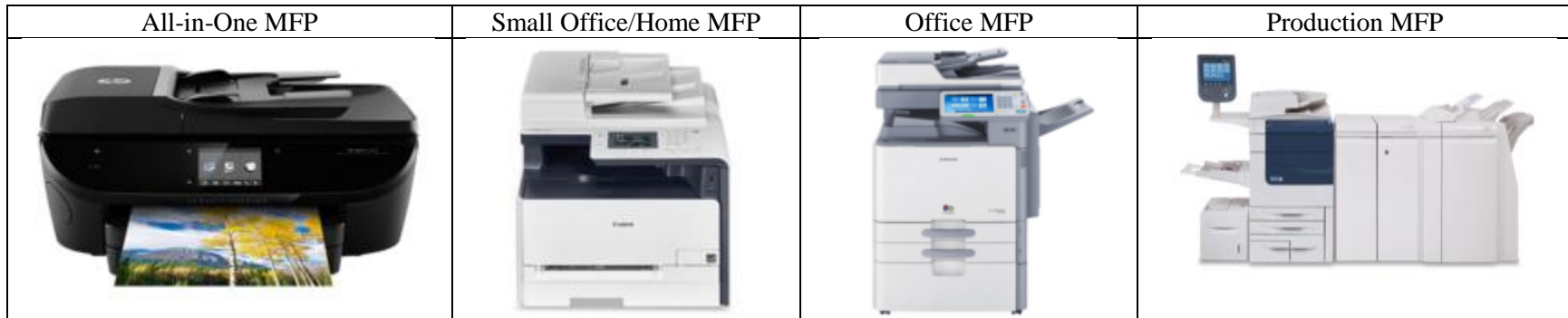
Attribute	Gasoline	Diesel	Natural Gas	Vapor Propane	Liquid Propane	Solar Battery Backup
Engine Cost	Excellent	Medium (for larger sizes)	Varies (Higher for larger sizes)	Varies (Higher for larger sizes)	Varies (Higher for larger sizes)	Very Poor (\$10,000-\$26,000 plus cost of panels)
Fuel Storage Cost	Poor (for larger sizes)	Poor (for larger sizes)	Excellent (if service available)	Medium (if large enough tank)	Medium (if large enough tank)	Excellent
Safety	Poor (flammable)	Excellent (high flash point)	Poor (earthquake risk)	Medium (very rare leak risk)	Medium (very rare leak risk)	Excellent
Environmental Impact	Poor	Poor	Excellent	Excellent	Excellent	Excellent
Fuel Availability	Excellent	Medium (must be delivered)	Excellent (no need for storage)	Medium (must be delivered)	Medium (must be delivered)	Excellent
Cold Starting and Operation	Poor (forms gum deposit)	Medium (harder in cold temps)	Excellent	Medium (requires large tank)	Excellent	Excellent
Engine Life/Wear	Poor/medium	Excellent	Medium	Medium	Medium	Unknown

Based on this table, our group would suggest that CTPSA consider either gasoline or diesel powered generators because of their lower initial cost, which we believe is the most important of the attributes for the school. We believe that diesel would be the better option due to safety, operation and engine life/wear. A diesel generator would cost more so the decision would depend on the available funds at the time of purchase. However, diesel would be preferable if the school can afford it. Getting a generator is a short term concern for the school because power outages greatly hinder the school now and will only hinder it more once the KMC is implemented. We do not recommend solar battery backup due to a significantly high price for installation and operation, but it could be a plausible option once solar panels are already installed.

I.3 Photocopier Guide

MFP= multifunctional printer

Type of Printer	Cost	Volume Capacity	Speed	Additional Features
All-in-One MFP	\$150-\$600 ₱75,000 - ₱300,000	Very Low	Very Slow	None - simple print, scan and fax features
Small Office/Home MFP	\$300-\$700 ₱150,000 - ₱350,000	Low	Slow	<ul style="list-style-type: none"> • Internal memory • Document feeder
Office MFP	\$1,200-\$4,000 ₱600,000 - ₱2,000,000	Medium	Medium	<ul style="list-style-type: none"> • Internal memory • Document feeder • Additional Security • Stapling
Production MFP	\$8,000-\$25,000+ ₱4,000,000 - 12,000,000+	Very High	Very Fast	<ul style="list-style-type: none"> • Internal Memory • Stapling • 3-hole punch • Borderless print • Wireless connection • Document feeder



When it comes to photocopiers, it can be overwhelming to sort through the available data about features, production rates and prices. This guide is intended to assist CTPSA in understanding the differences in types of photocopiers. This way, the school can be sure that the model they purchase is sufficient for their needs and realistic financially. The information for this table and description below come from the following website: <http://www.businessnewsdaily.com/7898-choosing-a-digital-copier.html>. Obtaining a photocopier is a short term consideration that can be accomplished before the KMC is built and immediately benefit the school.

Above is a general overview of the types of photocopiers that exist today and the features they offer and pictures that represent how each type of printer generally appear. It is important to remember that these prices are representative of the cost of photocopiers in the United States. However, it can be expected that the prices are similar in Costa Rica.

All-in-One MFP's are most common for singular users in homes or offices. They are designed to handle very low volumes of printing and offer the slowest speeds (20-30 pages per minute). These types of models would not be able to handle the printing volume demands of a school and would quickly be overwhelmed which could lead to malfunction. We would not recommend this type of photocopier for CTPSA.

Small Office/Home MFP's are a slight improvement in quality from the All-in-One MFP's. They offer a few more features, most notably a document feeder which allows for a slight increase in speed and capacity. Still, the speed and volume that this type of photocopier offers is still relatively low, and once again would not be ideal for the needs of a school. Therefore, we believe that a Small Office/Home MFP would not be able to handle the printing needs of CTPSA.

An Office MFP is a significant improvement in quality over the first two types mentioned above. They offer even a few more features than the Small Office/Home MFP's, most importantly security features that would let the school control access to the printer. Even more important than the features it offers is the increase in print speed and volume capacity that it offers. These models are designed to handle the needs of a larger office or school. This means that the printer will be able to handle the volume needs of a school and will be less likely to malfunction from overuse. **This is why we recommend the Office MFP as the best option for CTPSA because this type of printer can handle the printing needs of the school while still being financially realistic.**

Production MFP's offer a variety of features along with the best speed and volume capacity out of all the types of photocopiers. One of the most useful features is that this type of photocopier can handle bigger sizes of paper and some can even print posters. However, the most alarming aspect of this type of printer is the price. Starting at \$8,000 and only going higher from there, these photocopiers are quite an investment and are usually used at printing centers and organizations that specialize in printing services. Simply due to the price of these models, we do not suggest this type of photocopier for CTPSA.

On the next page there are various resources that offer both pricing and information on features, speed and capacity of different models of photocopiers. In addition, there is information about organizations, both online and retail stores, which sell a variety of photocopiers in Costa Rica.

Websites with information about specific photocopier models (in Spanish):

http://www.ricoh.com.mx/products/models_listing.aspx?cid=103

<http://www.office.xerox.com/digital-printing-equipment/multifunction-printer/esmx.html>

http://www.cla.canon.com/cla/en/consumer/products/printers_multifunction

Online Stores with information/purchasing information:

<http://www.cotizaenlineacr.com/multifuncionales>

http://store.officedepot.co.cr/OnlineStore/BrowseDepartment.do?criteria=DE=3,SD=10,CL=1,ST=3,SO=2,&page_Skus=24&orderBy=F&flagName=MULTIFUNCIONES

Another retailer in Costa Rica that sells photocopiers

P.C. Lider de Costa Rica S.A.

Multiplaza Escazú Tel: 2201-7333

Email: ventas@pclider.com

I.4 Furniture and Classroom Setup Recommendations

Furniture in the KMC should be lightweight yet also sturdy. Tables and chairs on wheels and displays and whiteboards around the room make the space adaptable for many activities. Many companies exist that sell furniture specifically designed to outfit a collaborative classroom. In order to get the best furniture that is both sturdy as well as lightweight and portable, donations are not a good option. However, contacting the different companies, especially the ones that are local, would give a better chance of either a bulk discount or even possibly some degree of donation. As a separate deliverable for CTPSA, we included many catalogs and case studies from the companies outlining furniture availability and choices made by other organizations. These decisions centered around multifunctionality and flexibility but each time with a different scope.

Companies:

Company	Closest Location	Website	Supplies Offered
Steelcase	Integrated Workplace Environments Intl LTDA Santa Ana	steelcase.com	Tables, Chairs, Whiteboards
KI	All locations in USA, however worldwide delivery possible	ki.com	Tables, Chairs
Nova	All locations in USA, however worldwide delivery possible	novadesk.com	Tables, Chairs
Herman Miller	Office Designs S.A. San José	hermanmiller.com	Tables, Chairs

Example Pictures of Multifunctional Furniture and Supplies



In the table below are additional links that will be useful to CTPSA. The scope of the KMC may change after we leave Costa Rica, so it is important to have a variety of design resources and photos to properly fit the furniture to the purpose of the spaces.

http://www.ki.com/furniture-design-resources/planning-guides/	KI Furniture Planning Guides
http://www.ki.com/furniture-design-resources/images/	KI Image Library
https://www.steelcase.com/resources/furniture-images/?search=Steelcase%2CEducation	Steelcase Photos
https://www.steelcase.com/services/#financial-services	Financial tools from Steelcase that help organizations fit their budget
http://www.hermanmiller.com/research/topics/all-topics.html	Hernan Miller research topics that explore the best furniture choices for a variety of different needs

Based on their wide variety and local presence in Santa Ana, we recommend that CTPSA first reaches out to Steelcase and then Herman Miller. However, CTPSA should not look into specific furniture companies until the KMC has gained more approval and there are more definite dimensions and divisions for the KMC. Specific furniture selection is a long term decision, but the general concept of multifunctionality is important throughout the KMC’s design.

I.5 Computer Donation Organizations

Many organizations exist in Costa Rica and worldwide that donate computers to organizations including schools. Obtaining more computers is mainly a long term consideration for CTPSA as the KMC is approved and built, but contact with these organizations should be initiated in the short term future. CTPSA uses computers often in its technical education, and many of these organizations look for specific computer need.

- **Amigos of Costa Rica:** Amigos of Costa Rica is a non-profit organization that raises charitable donations to support sustainable change in Costa Rica through four areas of action: education; competitive capacities building; environmental conservancy and science and technology.
- **Kramden Institute:** Kramden Institute recently partnered with East Chapel Hill Rotary Club to deploy 105 Kramden laptops and 30 XO tablets to nine schools in Costa Rica. The laptops, equipped with the open-source Ubermix operating system in Spanish, will have access to internet provided by the Ministry of Education.
- **Reader to Reader:** The Computer Donation Program donates new computers, tablets and e-readers, and refurbished Dell and Apple computers to schools with strong need for access to technology. Computer labs have been built in New York City, on the Navajo Nation, the Hopi Nation, western Massachusetts, Costa Rica, Ghana, Kosovo, Nicaragua, and Trinidad & Tobago.
- **Global Digital Divide:** This organization accepts monetary and technology donations and then provides schools with new computers or other technological resources. It would be beneficial to contact the Costa Rican contact to assess the status of their donations.

Organization	Contact Information	Location
<p>Amigos of Costa Rica</p>  <p>AMIGOS OF COSTA RICA Asociación de los Costarricenses en los Estados Unidos</p>	<p>Phone: (506) 2246-5656 Email: info@amigosofcostarica.org Website: http://www.amigosofcostarica.org/</p>	<p>Guanacaste, CR</p>
<p>Kramden Institute of Technology</p>  <p>KRAMDEN INSTITUTE</p>	<p>Phone: 919-293-1133 Email: info@kramden.org Website: http://kramden.org/computers-for-costa-rica-schools/</p>	<p>Durham, NC</p>
<p>Reader to Reader</p>  <p>Reader to Reader, Inc. global literacy in action</p>	<p>Phone: 413-256-8595 Email: info@readertoreader.org Website: http://www.readertoreader.org/donationprograms/computers</p>	<p>Amherst, MA</p>
<p>Global Digital Divide</p>  <p>Global Digital Divide</p>	<p>Phone: 561-408-6294 Costa Rica Contact: (Pablo Mendez) 506 8876 6027 Website: http://www.globaldigitaldivide.org/</p>	<p>Palm Beach Gardens, FL</p>

I.6 Free Software for Implementation

Many free programs are available for CTPSA to download and implement in their classes. For English classes, worksheets and downloadable files are prevalent which would work especially well if the school gets a photocopier. Additionally, software with listening and speaking activities would be effective once CTPSA acquires better audio and recording equipment. We have also identified one accounting program, a free operating system, and a free equivalent of Microsoft Office.

Implementing new software into the curriculum is a short-term consideration that will be extended over the long-term with the new resources in the KMC. CTPSA should look into implementing these programs as soon as possible.




- To Learn English www.tolearnenglish.com - This website has a large variety of activities designed to teach English. The materials are online based and cannot be downloaded. There are placement tests to assess those who are new to the program. Hundred of exercises will assist English learners of all levels. One feature which is especially appealing for CTPSA is that users can establish Pen Pals with others worldwide, initiating connections that CTPSA wants to establish through the KMC. In addition to serious exercises, there are also games and fun activities to reinforce English skills.
- Talk English www.talkenglish.com - This website has an array of English speaking and listening resources. There are videos and listenings to improve listening comprehension. The website recommends apps for iPhone and Android devices. Talk English is an online software and the offline version can be downloaded for \$21 (€10000) for computers and is free for mobile devices.
- English Banana www.englishbanana.com - This website provides free English workbooks for download. There are approximately 20 workbooks which cover all levels of English learners. We have downloaded these resources and are giving them to CTPSA as a separate deliverable. There are also resources for teachers to guide their English teaching strategies.
- Duolingo www.duolingo.com - This is an application which is designed to build foreign language skills through small amount of practice daily. There is a computer based version as well as a mobile version. Duolingo has other languages other than English that native Spanish speakers can learn. This daily practice can provide a good supplement to those who are struggling or those who are ambitious.
- GnuCash www.gnucash.org - This free software is applicable for accounting classes. In our feedback from CTPSA Accounting teacher Edwin Montero, it has potential to help students in early units of Accounting. As CTPSA is able to implement this software into its accounting curriculum, more potential uses will likely emerge, as a focus or a supplementary software.

- Ubuntu www.ubuntu.com - Ubuntu is the most widely used free operating system. It is a Linux based operating system which can be installed on any computer through a flash drive. Learning to use Ubuntu is slightly more difficult than Windows or Mac operating systems, but it can utilize almost any program that others can.
- OpenOffice www.openoffice.org - Openoffice is a free equivalent of the Microsoft Office Applications (word, excel, etc...). They are almost identical to use, but have some slight differences in interface. It is important that CTPSA monitors the demands of companies that their students work for, as certain companies might require skills in the specific Microsoft program series. However, OpenOffice programs still provide an alternative if having Microsoft software is not possible.

I.7 Audio and Recording Equipment for English learning

Speakers, headphones, and recording equipment has the potential to immediately impact English classes at CTPSA. The school should reach out to the companies we recommend below to initiate a connection and inquire about any chances of donations or discounts. Obtaining this equipment is very important to the long term plans of the KMC but the equipment can easily be implemented before that time.

Speakers

Ceiling Speakers	Wall-Mounted Speakers	Portable Speakers
		

Ceiling speakers are a great option for classrooms. They blend into the ceiling, making the room seem less cluttered and more visually appealing. In addition, they are perfect for getting sound to all parts of a classroom. This type of speaker would be perfect for the KMC because of its functionality as well as its visual advantages. Homewyse.com estimates that installation of 6 ceiling speakers would cost an average of \$1,500.

Wall-mounted speakers are another option for classroom. This type of speaker stands out more, usually making them less appealing than the ceiling speakers. Additionally, in order to get the same sound all throughout the room you would need to make sure that the speakers are placed in multiple areas. This option is generally more affordable and installed easier than ceiling speakers, but many do not provide the distribution of sound and visual appeal that ceiling speakers would. There are many options for wall mounted speakers, and the prices would vary. However, the cheaper models could certainly be installed for less money than the ceiling speakers.

Portable speakers provide an entirely different feature that the other two types cannot. These speakers can be moved to different classes as necessary. Once again, this type of speakers have many options to choose from, offering a wide range in prices. For portable speakers that could produce sound to fill an entire class, models usually start around \$100 and can go up into the thousands of dollars. However, if CTPSA was able to find an affordable, quality portable speaker, then it would give them freedom to use it in any classroom in the school. The other advantage of portable speakers is that there is no need for professional installation.

Sonus is a company located in Escazú that specializes in installation of electronics for commercial and residential services that could help CTPSA understand the cost and benefits of different types of speakers.

SONUS[®]

Equipos de Sonido y Video

Sonus Equipos de Video y Sonido

Telephone: 2288-7777

Address: 300 meters west from Plaza Colonial, Escazú.

Website: <http://www.sonuscr.com/en/index.php>

Headphones

Headsets with Microphone



Shown above are the type of headsets that would be appropriate for the English classes at CTPSA. Providing these to students will allow them to record themselves speaking English and then playback the audio through the headphones. This would allow the students to evaluate themselves and improve their English. These headphones would also allow oral exams to be taken simultaneously, and then would allow the teachers to playback each student's recordings as many times as is necessary to evaluate them. Another positive aspect of these headphones is that they can be found online for as little as \$10-\$15 each. Koss is a common brand used for these types of headsets. These headsets are relatively inexpensive additions that have the potential to make a great impact on the way the students at CTPSA learn English.




For more information on Koss headsets:

<https://www.koss.com/headphones/headsets>

I.8 Book Donation Organizations

Obtaining textbooks and other books for students to reinforce their English reading skills has the potential to immediately impact students. One of the important concepts of the KMC is the collection and centralization of information, and acquiring books is one important aspect of this process. Acquiring books is a short term priority, so CTPSA should reach out the organizations we have identified. These organizations look to donate books to increase literacy and support education worldwide.

- **Hotel La Rosa:** This local organization has a program that donates books in English, French, and Spanish to schools in the Alajuela District. They are committed to helping Costa Rica achieve high literacy rates. They have donated over 5,000 books to seven local schools representing all grades and ages.
- **First Book:** This international organization empowers educators by providing resources to help elevate the quality of literacy programs, enrich the learning experience of children, enable teacher to create new curricula, and impart a love of reading to children.
- **Give a Book Foundation:** This international organization allocates old and new books donated to the foundation to schools in need. They currently have a partnership with the Sarapiquí Conservation Learning Center that is located in Costa Rica.
- **Reader to Reader:** This international organization is dedicated to expanding literacy and learning opportunities for communities in need. They currently have an international program with Beyond el Campo in Santa Cruz, Costa Rica, where they have built a public library and run literacy programs for all ages. There is also a program in Ghana that provides large textbook donations to universities across the country.

Organization	Contact Information	Location
<p>Hotel La Rosa</p> 	<p>Phone: +(506) 2433-2741 Email: info@larosadeamerica.com Website: https://larosadeamerica.com/book-donation-program-for-increased-literacy/</p>	<p>Alajuela, CR</p>
<p>First Book</p> 	<p>Phone: (866) READ-NOW or (866) 732-3669 (available 8am - 6pm EST) Email: help@firstbook.org Website: https://www.firstbook.org/receive-books</p>	<p>Washington DC</p>
<p>Give a Book Foundation Partner: Sarapiquí Conservation Learning Center</p>	<p>Email: givebooksaveourfuture@yahoo.com Website: http://www.giveabookfoundation.com/ Partner Website: http://www.learningcentercostarica.org/sclc-news/sclc-news-archives/46-give-a-book.html</p>	<p>Partner: Puerto Viejo de Sarapiquí, CR</p>
<p>Reader to Reader</p> 	<p>Phone: 413-256-8595 Email: info@readertoreader.org</p>	<p>Amherst, MA</p>

I.9 Networking Opportunities, Connections, and Alliances

The most significant aspect of the KMC is that it will house resources to facilitate worldwide collaboration. As a start, we have identified established organizations that bring schools together and initiate a mutually beneficial exchange of knowledge. CTPSA can contact and join some of these organizations right away, but others are more exclusive and only accept new members by invite. Regardless, we recommend that CTPSA sets ambitious goals with its outreach to these organizations even before the KMC is built.

- **Council on International Educational Exchange (CIEE):** CIEE is a program that encourages students to study abroad, both from and to the US. It coordinates host families, local coordinators, and more logistics. The program has grown to more than 1,600 students, representing 55 countries since 1995. This organization can help CTPSA grow and create more exchange programs.
- **Connect All Schools:** Connect All Schools is an initiative to increase collaborative work in schools and to connect schools in the US with schools worldwide. This organization promotes “language practice online with native speakers around the world” and would help CTPSA’s English program develop (“About this project | Connect all Schools,” 2016).
- **Global Schools Alliance (GSA):** This organization is an alliance of 9 schools who are top ranked in their own region. The alliance aims to improve the opportunities and abilities of each school through collaboration and runs a symposia and other conferences/gatherings worldwide in order to share resources among the different schools involved. The alliance is currently by invitation only, but hopes to have joining criteria soon. There are currently no schools from the Global Schools Alliance present in Central or South America, so CTPSA could be the first to reach out.
- **Green Schools Alliance:** This organization is an alliance of schools worldwide that promotes environmental consciousness and sustainability in schools. Their goal is to “connect and empower schools worldwide to lead the transformation to a sustainable future” (“About Us | Green Schools Alliance,” 2016). They could help CTPSA realize more ways in which they can conserve energy and create more sustainable initiatives on their campus.
- **The Alliance:** This organization seeks to promote and initiate more collaboration and knowledge exchange among schools. By joining the organization, schools are entered into a directory where their information can be accessed easily, which can improve CTPSA’s visibility online.

Organization	Website	Contact Information
<p>Council on International Educational Exchange (CIEE)</p> 	<p>https://www.ciee.org/</p>	<p>Address: Council on International Educational Exchange 300 Fore St. Portland, ME 04101 Phone: 207-553-4000 Fax: 207-553-4299 Email: CONTACT@CIEE.ORG</p>
<p>Connect All Schools</p> 	<p>http://www.connectallschools.org/home</p>	<p>Contact Form: http://www.connectallschools.org/contact</p>
<p>Global Schools' Alliance(GSA)</p> 	<p>http://www.globalschoolsalliance.org/</p>	<p>Address: Global Schools' Alliance Rabalderstraede 11 4000 Roskilde, Denmark Phone: +45 2070 5230 Email: lene@autens.dk</p>
<p>Green Schools Alliance</p> 	<p>http://www.greenschoolsalliance.org/</p>	<p>Address: Green Schools Alliance 1875 Connecticut Ave NW, 10th Floor Washington, DC 20009 USA Phone: 1-860-468-5289 Email: info@greenschoolsalliance.org</p>
<p>The Alliance</p> 	<p>http://www.theaccreditationalliance.com/index.html</p>	<p>Contact Form: http://www.theaccreditationalliance.com/contact.html</p>

Process for Improving Website and Implementing a Social Media Presence





In our preliminary recommendations for CTPSA to improve its website and social media presence, we were informed that a lack of manpower is a major obstacle for improvements that could be made. In order to account for this, we recommend that student volunteers, under the supervision of faculty, take responsibility in maintaining the social media pages and the website. Computer Networking students would have enough knowledge to maintain the website, and almost everyone would know how to use the social media pages. Students could also form an organization or a club which collaborates to find new content for the website or social media pages. Specific content that should go on the website and social media pages should include:

- Advertise large events at CTPSA - We learned that CTPSA has large events including a fashion show and other fundraising events which could get better attendance if they were advertised better. This is specifically an area that is very good for social media pages like Twitter and Facebook
- Pictures of events at the school - Giving the school more of a positive image on their website and social media will allow those who are viewing the school through those means a good first impression. Having students who are interested in photography submit pictures of the school could provide a collection of pictures of the school which could create a photo album on Facebook.
- Easy contact information - Because CTPSA wants to make educational connections around the world, they must be easily contacted if another organization is viewing the website and wants to make contact.

I.10 Selecting and Implementing Solar Panels for the KMC

Solar Panels should be utilized by CTPSA to reduce the amount of electricity consumption in the KMC. The following table shows the different types of solar panels that exist. All of this information is provided by Pure Energies Group, Inc.

https://www.google.com/url?q=https://pureenergies.com/us/how-solar-works/types-of-solar-panels/&sa=D&ust=1461839863782000&usg=AFQjCNGe6c7gb_f3wM64gg2CiF2pNX9gGg

Name	Monocrystalline Silicon (Single Silicon)	Polycrystalline Silicon (Multi-silicon)	BIPV (Building Integrated Photovoltaics)	Solar Thermal Panels
Picture				
Information	These panels are currently the most efficient types of panels. This type of panel is more expensive, but does not need a large quantity of panels. This makes them ideal for roofs.	These panels are less expensive to produce, compared to single Silicon panels. They are also less efficient. There is need for a large quantity of these panels	BIPV's can look like real roofing tiles. They are less efficient than conventional photovoltaics, so you need a sunny spacious roof to affect your electricity bill. They are not as durable as normal panels.	This solar panel is a water heating system. Some systems can provide heat and air conditioning.




The disadvantage of using solar panels is that energy is not obtained on cloudy or rainy days. Even so, it will be important to contact a company that specializes in solar power and saving money. They will be able to assess the land of CTPSA during a consultation and give information on the efficiency, quantity (amount of panels), and price of potential solar panels that would best fit CTPSA's environment and budget. The following table shows three potential Costa Rican companies that give consultation and install solar panels.

Name of Company	Website	Email	Phone	Address
Costa Rica Solar Solutions	http://crsolarsolutions.com/	solarinfo@crsolarsolutions.com	+506 4030 2024	Oeste de la cruz roja de Santa Ana 2.5 km Hacienda Paraiso, Santa Ana 10901, Costa Rica
IntiTech	http://www.intitechsolar.com/en/solar.html	info@intitechsolar.com	Tel: +506 2438 3246 +506 2438 3272 Mobile: +506 8814 7610	La Guacima Arriba de Alajuela, 20105 Costa Rica
Solar Costa Rica	http://www.solarcostarica.com/index.html	info.solarcostarica@gmail.com	Office: +506 2244 6369 +506 6118 0277	300 Meters East of the Catholic Cathedral San Rafael, Alajuela Costa Rica 20108

It should be noted that even though solar panels can have a high initial cost, it is recommended to ask the consultant for the amount of time for the return on investment.

I.11 LED Lighting Opportunities in Costa Rica

LED should be used in the KMC because they are very cost effective. Though the LED lighting is initially more expensive than incandescent lights and compact fluorescent lights (CFL), the efficiency of LED lighting make them the best choice. The basic comparison of LED, CFL, and incandescent lights can be seen in the following pictures.

			
	Incandescent	CFL	LED
Lifetime (Hour)	1 000	8 000	50 000
Lifetime (year)	1	7	60
Electricity used (Kw)	3285 Kwh/year	767 Kwh/year	329 Kwh/year
	VERY HIGH	LOW	VERY LOW
Operating cost	ZAR367/year	ZAR90/year	ZAR38/year
Turn on immediately	Yes	No	Yes
Sensitive to Humidity	Some	Yes	No
Durability	No – glass or filament break easily	No – glass break easily	Yes – LEDs are highly shock resistant
Environmental Impact			
Contains TOXIC Mercury	No	Yes	No

<https://www.powertime.co.za/en/blog/tag/lighting/>

With respect to the table above, ZAR stands for a South African currency, the Rand. The table below takes this currency and converts it to American dollars and Costa Rican colones.

A table of annual operating cost of different types of lighting (based off the picture from PowerTime)

	Incandescent	CFL	LED
South African Rand (ZAR)	ZAR 367	ZAR 90	ZAR 38
American Dollar (USD)	\$25.30	\$6.21	\$2.62
Costa Rican Colónes (COL)	₡13,548.82	₡3,322.60	₡1,402.87

Energy Savings for LED lights vs Incandescent vs CFL			
	Incandescent	CFL	LED
Life Span (In Hours)	1,500	10,000	50,000
Cost	\$1.50	\$3	\$20
Wattage	60 watts	14 watts	6 watts
Price of electricity/hour (\$.30/KWh)	\$0.02	\$0.004	\$0.002
<i>Electricity Cost Used Over 50k Hours</i>	\$900.00	\$210.00	\$90.00
Bulbs Needed for 50k Hours of Usage	40	5	1
Replacement Cost	\$60.00	\$15	0
Total 50,000 Hour Lighting Cost	\$940	\$225	<u>Only \$90!</u>

The following table lists two Costa Rican companies who specialize in LED lighting.

Name of Company	Website	Email	Phone	Address
Costa Rica Solar Solutions	http://crsolarsolutions.com	solarinfo@crsolarsolutions.com	8805 0965	Parrita, Puntarenas Costa Rica
Magic Solutions Technology Support	http://www.magicsolutionssa.com	contact@magicsolutionssa.com	Phone: (506)26435133 Fax: (506)26435133	Plaza Coral local 20, Jaco, Puntarenas Costa Rica 61101

<http://energy.sourceguides.com/businesses/byP/light/LEDLighting/byGeo/byC/CostaRica/CostaRica.shtml>

I.12 Material Selections and Considerations for the KMC

The roof of the KMC should be painted white or a light color to not absorb heat.

When designing the KMC, the use of local materials should also be considered. Geoff McCabe of Pura Vida Sunsets says that “a large part of sustainable building and design is supporting your local community and its economy whenever possible” (McCabe, 2016, para. 15). This supports both economic and environmental sustainability. A Costa Rican material that can be implemented into building design is a recycled roofing material that is made of plastic bags from a banana plantation in Limón. This roofing material should be considered because it is lightweight, lasts for decades, looks like simple clay roof tiles and is strong enough to be walked on without breaking tiles .

The following article from the Tico Times is a very good resource that informs the reader of the advantages and disadvantages of many different types of materials used in construction, while also listing many valuable “green building resources.” These resources include links to architects/designers, sites for building materials, and resources to learn more about green building certification. We highly recommend that you read the article to be more informed when speaking to architects.

Creating with nature:Green Building Basics

By: Steve Mack May 31, 2012

<http://www.ticotimes.net/2012/06/01/creating-with-nature-green-building-basics>

Some of the highlights of this article include:

- Wood
 - Potent element in the fight against climate change because of wood’s ability to trap carbon dioxide from the atmosphere in long-lasting buildings, furniture and other goods
- Bamboo
 - Bamboo grows quickly and is an even more effective as a buffer against climate change than wood.
- Concrete
 - Damaging to the environment, but low cost, versatile, and strong.
- Earth
 - Create structures that will retain nighttime coolness throughout the day
- Foam
 - Not easily biodegradable, but is extremely efficient in maintaining temperatures
- Metal
 - Ideal for a mild climate like Costa Rica’s
- Reutilized and Recycled materials
 - Local materials should be used whenever possible to avoid added cost and pollution

Appendix J: Standalone Executive Summary

The document that follows is a standalone version of the Executive Summary given earlier in the report.

Innovative Education and Classroom Design at Colegio Técnico Profesional de Santa Ana



Abstract

Innovation in schools provides new means to keep educational offerings up to date. Identifying unique and effective educational methods not currently utilized is an important first step in effective innovation. This project worked to initiate this process at Colegio Técnico Profesional de Santa Ana (CTPSA), a technical high school in San José, Costa Rica. We assisted in developing a Knowledge Management Center (KMC), a sustainable new building on campus that will provide space and resources to support student collaboration and connection beyond CTPSA. Through interviews, focus groups, and observations, we identified how collaborative teaching methods, flexible classroom design, and innovative resources outside of CTPSA can be implemented through the KMC to improve students' education.



WPI

Authors:

Mark DeVries
Mila Maynard
Peter Melander
Victoria Simpson

Advisors:

Professors Melissa Belz
and Derren Rosbach

Sponsor:

Colegio Técnico
Profesional de Santa Ana

Problem Statement

Innovation is vital in schools because it keeps educational offerings up to date with the demands of the world (Dlugash, 2014). Teachers and students are changing class structures to fit with the development of information and communication technology (Tamo, 2014). Schools are accessing larger collections of re-

sources, both digital and physical, to innovate teaching and improve learning.

Colegio Técnico Profesional de Santa Ana (CTPSA), a Costa Rican technical high school in San José, is planning a new building called the Knowledge Management Center (KMC) to house space for student collaboration and resources for distant educational

connections. The school is working to set an example for public technical high schools in Costa Rica by making the KMC innovative, environmentally sustainable, and inspirational to students.

The idea for this project originated when personnel associated with CTPSA identified that modern developments in education require that schools across the world are connected and benefiting from each other. Our project group had the opportunity to work closely with CTPSA to identify the best classroom resources, teaching methods, and design considerations that would further their educational mission and vision through the KMC.

Background

Three areas were of specific interest to our project: educational practices, learning resources, and

environmental sustainability, which are outlined below.

Evolving Educational Practices

The traditional classroom is based on the Teaching-Centered Paradigm, where a lecturing instructor transfers knowledge to passive, note-taking students (McManus, 2001). In contrast, modern teaching ideas center lessons around students by letting them guide discussions and collaborate with each other. Collaborative learning improves communication skills by providing opportunities to formulate and share ideas, which is a vital step in real world preparation.

Student and teacher roles in the modern style of teaching and learning are changing in that students are becoming more involved in the learning process, and teachers are viewed more as support for students.

Misión
El Colegio Técnico Profesional de Santa Ana forma profesionales técnicos, con valores éticos, morales, sociales y culturales que logren integrarse en el mercado laboral, de manera eficaz y responsable, para así generar movilidad social.

Mission
The Colegio Técnico Profesional de Santa Ana forms technical profesionas with etical, moral, social, and cultural values that integrate successfully in the labor market in an effective and responsible manner to generate social mobility.

Visión
Ser una institución de excelencia en el ámbito técnico y académico para la formación integral de profesionales que enfrenten con eficiencia y calidad su incorporación en el mercado laboral.

Vision
To be an institution of excellence in techincal and academic scope for the training of professionals that face with efficiency and quality their incorporation into the labor market.

*CTPSA's Educational Mission and Educational Vision
Originally in Spanish and translated into English*



Developing Appropriate Educational Resources

Modern schools require various resources to facilitate a diverse range of activities used to prepare students for college and the workforce. In particular, modern libraries serve as a centralized location where students can access databases of reading material, relevant software, and technological hardware to connect with students around the world.



Flexible classroom at Monterrey Institute of Technology and High Education, a school in Mexico City, Mexico (Thelmadatter, 2014)

Modern classrooms also need to be flexible and accommodate many different activities. Flexibility aids the learning process by allowing a space to quickly be set up for any given activity, satisfying the needs of all students

Sustainable Development

Costa Rica has made a commitment to carbon neutrality by 2021,

and it is important for schools across the country to commit to sustainability in designing and evolving new facilities (Edwards, 2014). Sustainability can be implemented into building design without compromising the functionality of the building, and can also focus on involving students to positively impact future generations (“Teaching Sustainability,” 2016).

Project Objectives

The goal of this project was to develop the framework for a sustainable and flexible collaborative learning space at Colegio Técnico Profesional de Santa Ana (CTPSA) that would encourage students to learn and expand their educational possibilities. To achieve this goal, we developed and completed the following four objectives:

1. Determine classroom resources and teaching methods currently in place at the school and evaluate student and teacher satisfaction with them
2. Investigate effective educational and sustainability initiatives already being implemented both in Costa Rica and internationally
3. Assess various educational and sustainability options in the scope of CTPSA’s financial conditions and curricular goals
4. Develop a comprehensive plan that identifies subsequent steps the school can take to realize their flexible and sustainable learning space



EVALUATE EDUCATION AT CTPSA

- Student Focus Group
- Faculty Focus Group
- Class Observations

EVALUATE OTHER TEACHING AND LEARNING

- Visit technical high school in Costa Rica
 - Tour and Observation
 - Interview with administration
- Interviews with Teaching and Learning professionals
 - Outside of Costa Rica

EVALUATE SUSTAINABLE DESIGN

- Visit sustainable campus
 - Interviews with professionals
- Interviews with sustainability professionals within Costa Rica

Outline of our investigative methods

Methods

Our group used action research which involves social engagement and challenging what is accepted as normal with the intent of improving a social issue. The data for this problem solving includes interviews, focus groups, observa-

tions, participant observations and accounts (Marelli, 2016).

We used focus groups of faculty and students and classroom observations to learn about CTPSA's current teaching methods and identify the use of collaboration and technological learning materials in the classroom. To gain a perspective of teaching methods and specific materials students use in classrooms outside of CTPSA, we toured and interviewed administration at another technical high school in Costa Rica and held interviews with teaching and learning personnel from Worcester Polytechnic Institute. Lastly, to investigate sustainability considerations for the KMC, we toured a sustainable campus in Costa Rica and interviewed individuals who specialize in implementing sustainability into buildings in tropical climates.

Outcomes

Assessment of CTPSA Reveals Potential for Improvement

The first work we did in Costa Rica was to familiarize ourselves with CTPSA's current educational practices, resources, students, and faculty. Speaking with our focus groups revealed that students and teachers are grateful for CTPSA's educational offerings but also ambitious in wanting to make im-

provements. Students and teachers identified that their classes are impeded by a lack of sufficient computers, audio recording and playback equipment, and books.

We recommended that CTPSA contact companies and institutions that donate relevant resources, and we outlined the process for contacting many of these specific organizations.



Mark discussing sustainability with a Special Projects Engineer at EARTH University

Proper Use of Resources Outweighs Quality of Resources

State-of-the-art resources serve no purpose if they are not used properly. We saw resources at CTPSA being used to their fullest potential even though they could be deemed obsolete, but also observed inefficient use of technology at multiple schools. The KMC is going to have innovative and valuable resources for teachers and students, but they will only be effective if they are used appropriately by the school.



Student desks arranged collaboratively at CTPSA

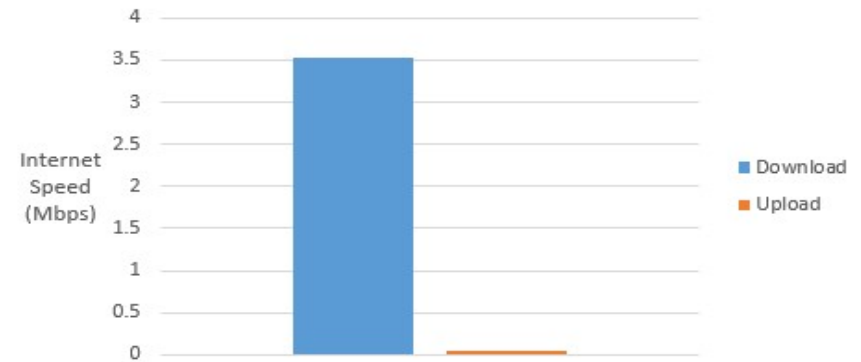
Improved Internet Promotes Innovation and Facilitates Connections

Internet is already an important resource at CTPSA, and it will become even more critical with the addition of the KMC. The quality of the current internet connection at the school is limiting the ability of teachers to incorporate online resources into their classes and the ability of CTPSA to make connections with other institutions.

CTPSA has the potential to improve its internet. Nationally, Costa Rica is continuing to improve internet for its citizens, and short term and long term improvements to internet infrastructure at CTPSA are possible as the school progresses towards the KMC (Agüero, 2016).

Multifunctionality is Key in the KMC

Internet Speed at CTPSA Megabits per Second (Mbps)



Average internet speed at CTPSA taken with 16 tests over 3 hours

The KMC will differ from academic classrooms in that it will be used by every student and teacher, so it has to have features that are adaptive and useful for a variety of activities. The spaces should benefit each student equally although they use the space differently.

Lightweight and movable yet sturdy tables and chairs make it easy for teachers and students to manipulate a space to fit their needs, and a variety of workspaces allows for easy student cooperation.

Since the KMC will have limited space but house many activities, multifunctionality is essential in its design and operation.

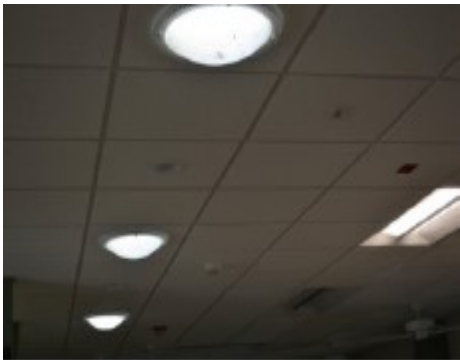


Multifunctional auditorium at Colegio Técnico Profesional de Educación Comercial y Servicios

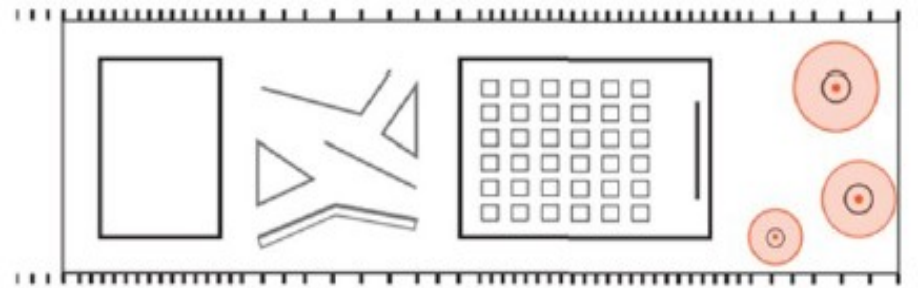


Design Freedom Allows for Sustainability

As CTPSA works with Katia Marten Arquitectos on the design of the KMC, it has been given the unique opportunity from the government to formulate a unique and sustainable but still functional building design. Cross ventilation, natural illumination, and vegetation are sustainable design considerations that are appropriate for the climate in Santa Ana which work to reduce electricity usage and conserve natural resources.



Passive solar lighting (left) compared to electric lighting (right)



*Katia Marten Arquitectos rough plan for the KMC
Property of Katia Marten Arquitectos*

Alternative energy could be used to help power the KMC, while other design considerations will allow the building to passively benefit from the environment. Keeping these considerations in the forefront of the design of the KMC will not only preserve the environment but also benefit its functionality.

Conclusion

The importance of education has made this project an exciting opportunity for our group to make a difference in the education of a very special group of students. From the beginning of our re-

search, our priority was to work successfully with Colegio Técnico Profesional de Santa Ana, allowing them to be involved in decisions regarding improvement of their school. As CTPSA continues to grow, the school seeks to have a building that can further strengthen their young professionals' practical technical capabilities. They wish to achieve it through a multi-functional learning space that incorporates local and distant collaboration to improve problem solving skills that will be known as the Knowledge Management Center. We hope that through our research

and recommendations, CTPSA will accomplish their goal of designing the KMC to be geared to strengthen its students' education with practical, appropriate, and sustainable technology.

“School improvement is a process, not an event. It takes place over an extended period of time, usually several years” (van den Berg & van Velzen, 1985, p. 59). This is the case for the KMC. We came to Costa Rica knowing that we must work within a reasonable scope, and the work we have done will serve as a solid foundation for CTPSA to accomplish their goal of the KMC. We are confident that future work by CTPSA faculty and outside volunteers will extend our recommendations, ultimately ending in the successful implementation of a new innovative, sustainable learning space.



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Acknowledgements

We would like to extend our sincere thanks to those who made this project possible

Professors Melissa Belz and Derren Rosbach

Worcester Polytechnic Institute

Colegio Técnico Profesional de Santa Ana

-Sergio Sepulveda, Ida Cortés, Renato Carranza, Fabiola Ruiz

Our interviewees and focus group participants

