A RECOMMENDATION FOR REMOTE LEARNING:

For Teaching Refrigeration as Sponsored by OST Buchs

An Interactive Qualifying Project Proposal

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Executive Summary

Problem:

OST Buchs University, located in Zurich, Switzerland has been looking to ensure that their new online course will be effective. With the Covid-19 pandemic, remote learning has come to the forefront as an important tool to teach students who cannot physically attend University. Classes that can be taught through an internet connection open up more educational opportunities for those who might not be able to access them otherwise. While the conditions behind Covid-19 remote learning are forced, this project seeks to build a recommendation of technology to use to host a permanent remote course. This course will allow students to learn about remote refrigeration technology from a different part of Switzerland, or even a different country. An OST Buchs graduate student has been working on creating a remotely-controlled refrigeration system, which would be used in conjunction with the class as a lab. This lab is to be used as part of a class with anywhere from 15-30 students, with approximately 25% of time being spent on labs. OST Buchs wants to make sure that this new course will be effective despite being online, and that students from developing countries could also be taught from the university remotely. The recommendation includes five different categories of platforms: a learning management system, a video conferencing tool, an interactive response tool, a remote desktop tool, and a scheduling tool.

Goals/Objectives:

The goal of our project was to craft two remote platform recommendations, one for students in developed countries, and one for students who are learning in developing countries. The goal for the remote platform recommendation for either situation was to identify all the

technology needed to effectively run the course from OST Buchs. Our objectives were to identify the unique challenges in teaching a course remotely in developed and developing countries, collect student and teacher feedback on technology they had used, and utilize the feedback to analyze current tools in remote teaching. Our final objective was to select the remote tool(s) that best fit the needs of students and teachers, and determine how they could be used in tandem with each other.

Methods:

To collect data on the current remote learning systems, we conducted cognitive interviews of students, teachers, and professionals from OST Buchs who were familiar with remote learning platforms. A cognitive interview is used to develop or improve survey questions, so it acted as a test run for survey questions (Haeger, Lambert, Kinzie, & Gieser, 2012). These interviews informed our surveys, as we could guide the interview to glean more information, but we could not guide the survey as easily once it was sent out. The interviews also ensured the questions we asked in the survey later were understandable. The interviews consisted of questions about their experience with remote learning systems, which informed us to what features of remote learning platforms did and did not work. We asked about what may have helped or hindered the students in self-taught classes. We administered the interviews remotely over Zoom and Microsoft Teams. The interviews were documented through written notes and video recordings during the interview, then transcribed using Microsoft Word's video-to-transcription feature.

After our interviews were complete, we did more research to find remote learning platforms for both developing and developed countries. We created a list not only for the survey, but for the recommendation, which we could use to compare the features of the platforms.

After we conducted these interviews, we created surveys that were passed out to a larger sample group of students and teachers at OST Buchs with possible remote learning experience. The questions can be seen in the appendix. For the teacher survey, we focused on what made teaching on a remote platform easier and more effective, while for the students we focused on what made a learning platform experience easier and more effective. We also used the surveys to collect more recommendations for remote learning platforms by asking students to add any remote learning platforms they had used that were not on our list.

The survey results were analyzed individually to find if factors like number of remote classes taught or years spent at University (teaching or as a student) had any impact on how the populations rated their remote learning experiences. By using the views of professors and students, in what they find to be important, we used that criteria to screen the remote learning platforms. These data points, along with the interview data, aided in the analysis of remote learning platforms towards our recommendation.

Findings:

Interview results:

After we had collected the results, we coded each interview based on common themes: types of media used in classes, importance of connection to others taking the course, importance of incentives/quizzes in classes, ease of use/simplicity, importance of interaction between teachers and students, and importance of immediate feedback when learning. After identifying parts of each interview that fit into different themes, we collected them into a document and condensed the quotes down into basic topics that could help us view the interviews through a different lens.

Survey Results:

From the survey results, it was clear both professors and students favored synchronous classes over asynchronous classes. This could be for a variety of reasons, including professors' desire to connect with students. There was no consensus between professors and students on how they rated each of their remote learning priorities, except on matters relating to presentations, audio, and the ability to get help. The most interesting deviations between the two groups were when asked to rate the importance of connection to students (peers in the case of the student survey) and the importance of having interactive responses during the lecture. Professors are split on whether or not they find interactive response important, whereas they favor having a strong connection with their students. Even for professors who had used video-based calling software, they still did not feel that they had good interaction with the students. The students, on the other hand, did not find feeling a connection with their fellow classmates a priority, while they did favor interactive response. Another curious result of the student survey is how much emphasis they placed on the content of learning materials, including presentations and audio explanations that the professor may give.

Within the student surveys, one main theme from the comments was the lack of social interaction in a remote classroom setting. Some students said they feel a disconnect from others, which highlights a problem in today's online learning platforms. Another student commented that they missed the "communication between classmates". While the survey results did not list this as an important aspect of remote classes, they did nonetheless complain about this lack of community. This may simply be the result of having to switch from an in-person class to a remote class due to COVID-19. Another issue that students brought up was internet connection.

A stable connection is important, because it improves real-time feedback and interaction when trying to give a video conference lecture.

Recommendations:

Developed Countries:

Our recommendation on how to best teach the remote refrigeration course at OST in developed countries includes five different categories of platforms: a learning management system, a video conferencing tool, an interactive response tool, a remote desktop tool, and a scheduling tool. For a LMS we wanted to find a platform that included a file cloud system, video conferencing capabilities, and would integrate well at OST. We recommend **Moodle** because it fits all of our criteria and experience with the platform warrants a much smoother transition, but Canvas, Blackboard and D2L would also work. Similarly, most of the video conferencing platforms included all of the features we wanted: an interactive whiteboard, conference recording, and chat functions. We recommend **Microsoft Teams** for OST Buchs because it has all of the desirable functions and is part of the Office 365 system that the university already has for students and professors. Since the university licenses Office 365, we also recommend **Microsoft Forms** as an interactive polling response. Ideally, accessing the lab would occur through a web interface that could be integrated into the LMS. Unfortunately, there are no easy ways of connecting a remote lab to the web. For this reason, we suggest using a remote desktop tool in conjunction with a scheduling tool. However, should a web interface be desirable, we suggest looking into developing a Moodle plugin using either WebLabLib or Easy Java/JavaScript Simulations. Those that develop the web app will have a better idea on what libraries and internal tools to use. The remote desktop recommendation is to use **Splashtop**, since it provides easy access to students on and off campus. Since remote desktops can only be

accessed by one person at a time, there needs to be some way to schedule lab sessions. We recommend **Calendly** as a lab appointment scheduler due to its LMS integration feature and the simplicity of using the platform. These platforms and tools used in conjunction with each other comprise our recommendation for OST Buch's course that will be taught in developed countries.

Developing Countries:

Creating the recommendation for developing countries was naturally different from the recommendation for developed countries. Our developing countries recommendation was focused more on accommodating students with limited internet access time. For this situation, we narrowed our focus to LMSs with strong offline capabilities. Any programs we chose would also need to be fully compatible on mobile devices such as tablets or smartphones. We recommend using **Rumie** for the lecture content because it has strong offline learning capabilities and can be used on virtually any mobile device. Rumie uses videos as its primary learning tool that can be downloaded onto a device with internet connection and can then be accessed on the same device with or without internet connection. For the lab portion, an internet connection will be needed in order to access the remote desktop. **Splashtop** is also our recommended remote desktop for developing countries due to its ease of use, and mobile capability. This will mean that only one type of remote desktop application will have to be used on the remote lab system. We recommend **Calendly** as a lab appointment scheduler due to its LMS integration feature and the simplicity of using the platform. These three platforms together comprise our recommendation to best teach a technical course in developing countries.

Abstract

Remote learning has been more prevalent now more than ever due to the current pandemic. The goal of this project is to create a recommendation for our sponsor, OST Buchs, with a way to easily integrate a remote technical course. This recommendation also includes ways for this to be done in developing countries at the graduate level. The results of this project show that the platforms we recommend are not a “cure-all” solution for a remote technical course, but merely take into account the needs of students and professors. The recommendation for developing countries took many factors into consideration in order to provide platforms that best suit their limitations. A general standpoint was also taken so that other universities can take our recommendations for their personal use.

Acknowledgements

Our entire team would like to thank the sponsor of the project, OST Buchs. Professor Stefan Bertsch from OST has worked closely with use throughout the duration of our project. Professor Bertsch helped us with our data collection: sending out our surveys, and provided contacts for interviews. We could not have done this project without his help and responsiveness.

We would also like to give a special thanks to Jan Semüller, a graduate student at OST Buchs. In addition to developing the remote refrigeration system that contributed to a big portion of our project, he was eager to lend a hand to us when he was able. He provided very useful information on how the system works and how interaction and limitations of the system is handled.

We would like to thank our advisors Professors Blake Currier and Ulrike Brisson for all the hours they put in to help us with this project. Their guidance and feedback was really beneficial to use throughout the project. And also a big thanks to Professor Brisson for sharing homemade Swiss treats at almost every team meeting.

Lastly, we would like to thank OST Buchs and Worcester Polytechnic Institute for allowing us to complete this project remotely and dealing with all the difficulties of the current pandemic.

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CHAPTER 1: INTRODUCTION

With the current Covid-19 pandemic shutting down traditional forms of education, there has been a race to convert classes into a remote format. The transition to a remote format is especially difficult for classes that include a lab element. Thankfully, with the advent of remote laboratories, students can participate in traditionally “hands-on” activities remotely. Classes that can be accessed with an internet connection open up more educational opportunities for those who might not be able to access them otherwise, especially in important but overlooked fields. Control refrigeration engineering is one such field that requires planning to convert to an online format. It has become necessary to research how to make these classes more effective.

OST Buchs University is currently looking to ensure that their new online refrigeration course will be effective. An OST Buchs student has been working on creating a remotely controlled refrigeration lab. This lab is to be used as part of a class with anywhere from 15-30 students, with approximately 25% of time being spent on labs. We created a recommendation on remote learning platforms and tools that will best suit the needs of remote technical classes. This recommendation can then be applied to classes at OST Buchs on refrigeration systems.

Due to the Covid-19 pandemic, there is a vast amount of data from the students and teachers who have been forced into a situation where remote classes have become necessary. Although most of these classes were not extensively planned due to time constraints, the students and professors now have a better idea of what does and does not work. Along with this, the number of remote students enrolled in universities, despite the pandemic, has also been increasing over the past few years. This has forced universities to cultivate a vast amount of knowledge on what practices form the ideal remote learning class. In addition, there has been an

increase in remote learning for industry professionals over the past years. We tapped into existing and new sources of information in order to create our recommendation. We primarily looked at information pertaining to the primary concerns of professors and students, and what they found difficult when taking classes remotely.

To aid OST Buchs with the development of their remote refrigeration module, we created a recommendation on what tools to utilize for remote experimentation classes. We furthered our recommendation so it fit the needs of OST Buchs and the needs of students in developing countries who may be able to access this technology.

CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

The sponsor of our project, OST (Ostschweizer Fachhochschule), has given us the task of creating a recommendation for how they should structure their remote refrigeration class. OST Buchs is a technical college in Buchs, Switzerland. The campus, formerly known as NTB Buchs, is known for their systems technology programs, of which they offer undergraduate and graduate options. In 2020, they merged into the Eastern Switzerland University of Applied Sciences (OST).

This recommendation will be used to determine which platform OST should use to teach students about refrigeration systems, along with a remote laboratory system. A substantial amount of research on remote teaching and remote laboratory systems was needed to better understand which remote platforms will work best for the OST curriculum. We created a recommendation that applies to any remotely taught technical course, however we included OST's refrigeration system to be used as an example and a basis for the technical application of our recommendation.

Online Teaching Methodologies

When looking at how to format an online class, it is important to understand the different ways that information can be presented. There are two main methods for teaching in today's culture, didactic teaching, and participatory teaching. Participatory teaching is often called project-based learning and excels in teaching practical skills (Gal et al, 2018). Participatory teaching often requires more interaction between teachers and students, as is suggested by it's name. Participatory teaching has also been shown to boost the students' overall performance in class (Gal et al, 2018). However, it requires a greater time commitment on the part of the

students and the teachers (Moreno López et al, 2009). Didactic teaching refers to the method of teaching where information is presented to students, who are then responsible for absorbing the information (Pekda & Azizolu, 2013). In addition, the benefits of participatory learning are lessened if the student has recently taken a course at a similar difficulty that utilized a didactic teaching model (Gal et al, 2018). When there are limited opportunities to have interaction between students and teachers, it becomes obvious that the majority of the course will have to be taught using didactic methods, with some assessment or assignments to solidify understanding when available. Methods of remote participatory teaching logistics will be further explained in later sections.

Different Forms of Didactic Teaching

There are three main strategies of didactic teaching: empirical strategy, problem-solving strategy, and modelling strategy. In the empirical strategy, the teacher presents the students with new information and the students process this information and integrate it into their existing knowledge (Enikő, 2013). The problem-solving strategy involves presenting the students with a problem that they cannot solve based solely on their existing knowledge and must seek out new information (Enikő, 2013).The modelling strategy involves the construction of knowledge in one's internal thoughts, modelling this through images, symbols, or code, then using these models to verbalize this knowledge. Anytime a teacher demonstrates any concept in any way, that teacher is using the modelling strategy (Haston, 2017). As a person learns new information, that person incorporates this into their already existing model (Enikő, 2013).

What Makes a Successful Online Class

When discussing which of these models is the best for students, there is no clear answer (Enikő, 2013). This is due to the range of options that teachers have when interpreting the

different teaching models. However, there are multiple strategies for making any of the teaching methods listed above more effective. First, it is important to make a conscientious and consistent decision on what teaching method to utilize (Enikő, 2013). This does not necessarily mean following one of these methods to the letter, just that the teachers make a choice on how to deliver the information. This decision is to be based on the needs of the students, the topics being covered, and the environment in which the class is taking place (Finn, 2020). Again, it is important to note that there is no one answer when asking what overall strategies to use in an online class. The main takeaway is that the teacher must look at their own strengths, and the strengths of their students, and make a clear and consistent decision on how to run the class. However, there is some advice that pertains to all teaching, that becomes especially important in remote learning. One of these being that the needs of the students should be reassessed at routine intervals (Macdonald & Cambell, 2012). This ensures that certain topics, which can act as roadblocks to understanding the rest of the course, are fully understood by the students. In the classic classroom, this takes the form of a teacher adjusting the course to spend more time on a topic that the students do not understand. In online classes, this may mean an increased number of small assessments, as it is harder for a teacher to visually gauge students' understanding while teaching. Course adjustments may also include additional resources and information based on the student's personal interests (Hus & Grmek, 2011). This approach has increased students' performance in assessments. This is a particular challenge when the course takes the form of a self-taught module. These adjustments might take the form of additional modules that could augment the curriculum. Regardless of the method, student needs should be addressed in some way in order to ensure that they have ample opportunities to understand the material that is presented to them.

Current Tools Used in Remote Learning/Laboratory Systems

One cornerstone of our project was identifying a way to connect with the remote refrigeration system constructed at OST Buchs. This system is outfitted with a number of sensors that will allow users to remotely practice monitoring and controlling the refrigeration unit. In this section, we'll discuss what software is currently in use for control engineering curriculum, and how we could learn from these previous projects into our recommendation for a remote access system.

One important distinction to make is the difference between live remote laboratories and simulated remote laboratories. Some systems, rather than accessing the controller of an actual working refrigeration unit, merely mimic the system to be controlled. Simulated remote laboratories (Fabrega, 1686) have the benefit of not going through the process of remotely connecting to a control server. In addition, no one has to prep and schedule the actual system between uses, meaning it can be accessed on a flexible schedule. There are many laboratory simulation platforms that already exist and are not in the scope of our focus on remote laboratories.

Remote Laboratory Systems

Remote lab systems are used for control and telemetry access to a specific piece of equipment in a laboratory. With remote access, an engineer can control and monitor the system without needing to be in the same physical space as the system. In recent years, these systems have become more plentiful with the internet and personal computers.

There are a few key factors to keep in mind when creating a remote laboratory system. The first is how the data coming from the system will be visualized for the student. Fabregas suggests that "without suitable visualization, remote laboratories can be hard to understand for many students" (Fabregas, 2011). The author points out that while in-person users of a system can rely on real-life cues when making changes, a remote user can only see basic data coming from the refrigeration system. Therefore, it was very important that when we created our recommendation for a remote laboratory platform, we made informed choices about how we presented that data.

LabVIEW, by National Instruments, provides a way to handle the data coming from the system using a controller made by National Instruments. LabVIEW can work in combination with other client-side software or on both the server and client-side software. One article by Chandra, describes how a mobile phone can be turned into a remote laboratory tool by installing the Smartphone Cross-platform Control Kit, where "the student at the client only needs to run the application file with LabVIEW Run-time engine installed" (Chandra, 2014). Making the remote laboratory accessible by mobile devices would allow the learning program also to be easily implemented in developing countries, where mobile network access can be easier to find than internet access. Due to the expensive price, the graduate student who built the system did not suggest that we use it as our stand-alone remote laboratory suggestion. LabVIEW would have worked great to fit the courses' needs but was not an option so we looked into some cheaper options.

There are many choices when it comes to remote laboratory software, both on the server-side (the side that handles the control system), and the client-side (the side that the user sees). Fabregas suggests that Easy Java Simulations can be used as an interface on the client-side,

while Simulink software is used to control the refrigeration system being accessed. Easy Java Simulations has the benefit of being fast to develop "without special programming skills" (Fabregas, 2011). However, there will still be some development time associated with this tool. We also found a python library that claims to allow for easy integration between a remote laboratory and a website. In order to use either of these options for the refrigeration system, someone would have to design the web interface and perhaps use one of these libraries in order to create a purely web-based solution.

Another method of controlling refrigeration system remotely is called a **remote desktop**. A remote desktop gives the user control over the host computer, which goes on to control the refrigeration system locally. In our example of the refrigeration system, this would allow the user to run existing control software for the refrigerator on the host computer. The difference between using a remote desktop and a **remote connection software** is where the control takes place. Remote connection software refers to programs such as the EasyJava Simulation library stated above. Remote desktops allow one computer to control another, whereas remote connection software merely provides an interface for specific interactions. Remote connection software is like the two computers conversing on how to control the refrigeration system, whereas a remote desktop is one computer directly controlling the other. This means that the communication for remote desktops is "extremely asymmetric, while most of the data will go from the server to the client" (Reiner, 2020). For the refrigeration system, a remote desktop allows the user to command the host computer to execute a specific function (e.g. increasing the temperature of the system), which would then control the refrigeration system to carry out that function. Remote desktop software has widespread use in a variety of applications. This means you do not need a remote connection software that connects to specific programs, saving you time and money

compared to creating a remote connection software. However, the individual connected to the host computer is also able to conduct other operations on the host computer, operations that would not be possible if there was specialized software merely creating an interface between the two.

Remote Learning Platforms

The main focus of our project was crafting a recommendation for a remote learning system through didactic teaching materials. In addition to OST Buchs, this learning system should be accessible to students of developing countries. There are many learning platforms currently available that we looked into to familiarize ourselves with the features of each one. Moreover, there are several educational tools that can be used in conjunction with a central learning management system (LMS) platform. A LMS is a software application for automating and administering the delivery of educational content (Ellis, 2009). There are several existing LMS platforms that are shown in **Table 1** that we wanted to familiarize ourselves with. Although an LMS can be used as a standalone teaching platform, we wanted to implement plugins and integrable learning tools to help make the course more effective. We compiled a list of different tools, as shown in **Table 2**, that we looked into and sorted them by their primary function.

We decided that a traditional LMS would not be a good fit as a central platform for developing countries with limited internet access. A traditional LMS requires consistent internet access to keep it updated and to use it. Instead, we looked into digital microlearning libraries or open-source learning platforms such as Rumie for teaching lecture content in developing countries. These types of platforms allow all the learning content to be downloaded ahead of time and can then be used offline. This reduces the need for a constant internet connection.

OST will be given our final recommendation on how to effectively teach a technical course remotely. They can use our recommendation for any class, but specifically for their course using their new refrigeration system for their lab.

LMS Platforms	**Microlearning Library**
Blackboard	Rumie
Canvas	Kolibri
D2L	
Edvance360	
Moodle	
Sakai	

Table 1: Learning Management Systems and Microlearning Libraries

Platform Types			
Video Conferencing	**Interactive Response**	**Remote Connection**	**Scheduling**
Adobe Connect	Microsoft Forms	ConnectWise Control	Calendly
BigBlueButton	Poll Everywhere	GoToMyPC	Google Calendar
Cisco Webex	TurningPoint	Splashtop	Outlook Calendar
Discord		Teamviewer	Picktime
GoToMeeting		Windows Remote Desktop Connection	Setmore
Kaltura			
Microsoft Teams			
Zoom			

Table 2: Remote Learning Platforms Listed by Category

Remote Technical Course Example Using Remote Refrigeration System

Jan Segmüller, a graduate student at OST, put together a remotely accessible refrigeration system for his master's thesis. The idea behind it was for students to be able to remotely connect to it via remote desktop for learning purposes with potential to be incorporated in virtual labs as well. This system-roughly amounting to $30,000 in equipment is equipped with the necessary tools to make up a refrigeration system, such as a compressor, condenser, expansion valve, an evaporator, and the necessary electrical components (see Figure 1). It also has various temperature and pressure sensors that can be regulated remotely for students to learn how the system can react to different variable changes.

The system is controlled by a cDAQ (Compact Data Acquisition), which can control all of the sensors and data transfer of the refrigeration cycle. In order to interact with the system, a program called LabView is used. To do this, a student would have to use a remote desktop to connect to the laptop connected to the refrigerator. From there, the student may interface with the system for various learning purposes.

In order for this system to be integrated into a remote technical course, lectures and labs would have to be refined. For lecture, professors will need to teach basic thermodynamic principles so that students will understand the basics of refrigerators and how they work. Once students have a background of the system and its application, they can interface with it in a lab setting. The system, however, has a few limitations. The system so far, can only be operated by one person at a time through a remote connection, and must have someone to physically be with the system to make sure nothing goes wrong. Also, the system has built in fail-safes so that a student cannot input an arbitrary value to throw it off. Aside from these limitations, we will talk

further on our recommendations on different platforms in order to fully interact and learn about refrigeration systems.

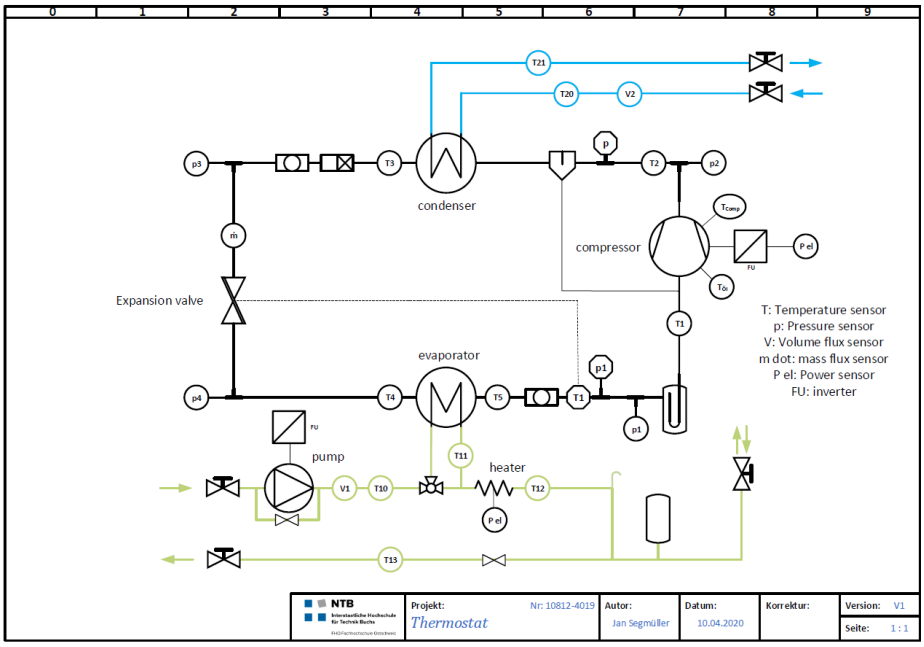

Figure 1: Schematic for the Refrigeration Cycle

Importance of Accessibility in Developing Countries for Graduate Level Education

Developing countries are in need of remote learning, however they lack certain technology in order to upgrade to this style of learning. There are several reasons that limit developing countries from introducing remote learning including lack of stable internet connection. However, educational technologies are becoming more available and affordable for

developing countries and communities, especially those at university. This introduction of mobile learning, which is defined as “a way to learn independently at anytime, anywhere due to advancements in mobile technologies” (Imtinan, 2012), is an important solution to improve the education standard. Mobile learning for developing countries can help with problems such as cost and slow internet. Multiple mobile learning studies have shown encouraging outcomes in developing countries and motivate further research in introducing mobile learning (Imtinan, 2012).

E-learning technologies include many ways of implementation such as television, radio, CD’s, DVD’s, video conferencing, mobile technologies, and electronic learning platforms. One university in Tanzania, Sokoine University of Agriculture, has implemented learning management systems such as Moodle, which is used by universities and organizations worldwide, to help professors and educators offer effective online learning communities in that country (Sife, 2007). However, we will keep in mind that students may always not have access to the university. We made sure that our recommendation took this into account by recommending a platform with low internet and cost demands.

In order to screen these E-learning technologies, we conducted online research to gather information on the advantages and disadvantages of each which led us to our decision on our final recommendation. We will discuss this further in the methods section.

CHAPTER 3: METHODS

The goal of this project was to help OST Buchs by recommending remote learning platforms and strategies for using these platforms for a refrigeration system that they are currently developing. Our team carried out this task through multiple objectives. First, we gathered feedback on remote learning systems through interviews and surveys. We analyzed this data in order to incorporate important feedback into our own work. Afterwards, we used this feedback to figure out the criteria for the different remote learning platforms. Then we screened platforms based on these criteria. Finally, we made a recommendation to OST Buchs about what platforms would be most practical for remote learning, teleconferencing, remote lab connection, and lab scheduling. We also recommended strategies for using these platforms, and how they could be most effectively implemented.

Gathering Teachers' and Students' Feedback on Remote Learning Platforms

To collect data on the current remote learning systems, we conducted cognitive interviews of students, teachers, and professionals from OST Buchs who were familiar with remote learning platforms. A cognitive interview is used to develop or improve survey questions, so it acted as a test run for survey questions (Haeger, Lambert, Kinzie, & Gieser, 2012). These interviews informed our surveys, as we could guide the interview to glean more information, but we could not guide the survey as easily after it was sent out. The interviews also ensured the questions we asked in the survey later were understandable. We administered the interviews over Zoom and Microsoft Teams. The interviews were documented through written notes during the interview and video recordings during the interview, then transcriptions using Microsoft Word's video-to-transcription feature. The interviews consisted of questions about their experience with

remote learning systems. Each interview session lasted about 10-20 minutes. The answers to the questions informed us to what features of remote learning platforms work, and which do not work. We asked about what may have helped or hindered the students in self-taught classes. After we conducted these interviews, we created surveys that were passed out to a larger group of students and teachers at OST Buchs with possible remote learning experience.

After collecting and analyzing the data from our interviews, we created our survey questions for professor and student surveys. These questions can be seen in Appendix B. For professors, we were interested in the number of remote classes they had taught, and what made remote learning easier to teach. For students, we were interested in the number of remote classes they had experienced, and what made remote learning more effective for them. By collecting the number of remote courses, they had taken, we could gather how much experience they had with remote learning, and whether their opinions changed with more exposure to remote learning. We inferred that most students at the time of the survey being sent out had some experience with remote learning due to the Covid-19 pandemic. We also asked students to rate and highlight the flaws of their remote learning experience. For both professors and students, we asked them to rate a list of remote learning platforms that we collected through survey responses and previous research.

Analysis of Data

In order to analyze our interview results, we made sure to record each of the interviews. Once we had a video from each interview, we used Microsoft Word's transcription feature to convert the interview videos into text. After getting our results into a text-based format, we removed all the unnecessary speech from the interview. Small talk not pertaining to what we

were interested in got cut. The transcription service had transcribed all the speech in the videos, and so excess words were removed from the interviews. Once we removed unnecessary words, we made word clouds from the interviews to help visually identify certain aspects and similarities of each interview. After removing the chaff and dissecting these word clouds, we began color coding our interviews.

To code our interviews, we identified common themes between them. The themes we chose were guided by our interview notes, and from reading through the transcriptions. The themes included: comments on media types, connection to others, importance of incentives/quizzes, ease of use/simplicity, ability to interact, and immediate feedback. After listing these themes, we gave each theme a color and began to highlight quotes from the interviews. Once we had a highlighted transcript and listed out the identified quotes for each theme, we began to condense those quotes into a list of more specific parts for each theme. This gave us the commonalities from interviews and gave us more insight into the interviews as a whole.

The surveys were sent to two different populations, students, and professors. Between the two different surveys, there were a total of 27 responses. This included 11 professors, which represents one-third of the professors at OST Buchs. Our aim was to compare and contrast what students and professors found important for their remote classes. The survey results were also analyzed individually to find if factors like number of remote classes taught or years spent at University (teaching or as a student) had any impact on how the populations rated their remote learning experiences. By utilizing the views of professors and students, in what they find to be important, we used that criteria to screen the remote learning platforms.

For the final step, we drew a conclusion from our analysis. We utilized this data to create points of comparison for remote learning platforms and found out what features are important for both students and professors. These data points aided in the analysis of remote learning platforms.

Screening Remote Learning Solutions

After collecting interview and survey data on what did and did not work for students in self-taught class modules, we used the data to create a list of criteria for a remote learning platform. This was in order to make sure that the criteria are based on the opinions of students and professors. The criteria were based on what we found worked best for students using the data we collected from the surveys and interviews. Luckily, we are not the first ones to create criteria for remote learning systems.

We were able to compile a list of remote learning platforms that we could ask students and professors about in our interviews and surveys. We added to our list of remote learning platforms from our interviews and surveys and updated our survey questions accordingly, using a UNESCO site that lists out remote learning platforms (UNESCO, 2020) . Stevenson defines this process as multi-step data collection. (Stevenson, 2010). This allowed us to compile a list of online learning solutions, while gathering data on the effectiveness of each through our surveys and interviews.

After creating a list of remote learning platforms, we categorized the platforms by major function. We then used our survey and interview data to create criteria for each category of remote learning. After creating the criteria list, we used Microsoft Excel to list out the learning platform choices, and what criteria each of them fit. As an example, the criteria for remote learning platforms included whether it had offline capabilities for developing countries, or cloud

integration for developed countries. These criteria were refined from the opinions of students and professors, as well as differences we found while researching and meetings we had with OST Buchs. We then used a visual device, frequency mapping, to analyze what learning platforms work best for remote learning (De Munck & Juliana Flinn, 1998). This allowed us to select the best remote learning platforms for OST Buchs.

Creating a Comprehensive Recommendation for OST Buchs

After collecting data from the previous objectives, we built the data into a recommendation on what platforms could be used for the remote refrigeration course. This recommendation included suggested platforms and strategies for the coordination and use of the remote refrigeration system.

CHAPTER 4: RESULTS

Through this evaluation and analysis of our collected data, we created a set of criteria for the remote learning platforms and tools that we recommended to OST for their technical remote classes. Our interviews provided useful insight about the current remote learning systems that are being used, and what does and does not harbor an effective remote learning environment for students. For developed countries, we recommended a platform with synchronous class abilities, easy feedback accessibility, and a file upload system. For developing countries at the graduate level, we recommended platforms that are low-cost and do not rely on constant internet connection. Our survey furthered our knowledge from students and professors about the tools and features that they believe are the most effective. The surveys also allowed us to collect results from a wider audience, which gave us confirmation that the data from the interviews were

not based on a very small percent of the student population. We screened remote learning platforms with this information in mind to find the best recommendation.

Interview Results

As we started out, the first step in collecting data was to conduct interviews with both students and teachers. We asked each individual a set of questions, which can be seen in Appendix A. This took up the majority of our data collecting time between conducting the interviews, transcribing the data, and sorting out the data from the notes/transcripts. While we used the initial notes from each interview to guide creation of the surveys, we used parts of the interview transcripts as data points for our report.

After coding the interviews, we had a few interesting insights into the part that types of media played in education. Among many of the interview participants, there was a consistent interest in video-based learning of some kind. Most of the videos the interview participants talked about were from classes where the professor took a video of their screen while providing voice over for the lecture. This was useful, as some of the participants described, because "[you] had access to all the information and you could rewatch it." That student also mentioned that they continued to use those videos in their professional career. The student made it clear that it was important that the learning media could be kept after the class had ended. However, there were some negative opinions on video-based learning. One study participant, speaking about the online open course site Coursera, said that learning on the website was "very difficult in the sense that because they were just videos. I would watch the videos, but then you probably don't have a grasp on what you're meant to learn...by just watching the videos…" If you only watch the videos, the student said, you don't know what you need to learn as much as if you had a professor to teach you and give feedback. Any comments on the topic of text-based learning

were negative, with the interview participant who brought up text-based learning saying they skimmed the written material if it was “too boring”. The main point that came up during that interview was about how reading PDFs and other learning documents can be a chore to students, and is often skipped if they think they know what the text is trying to convey. This suggests that classes should feature more video/audio resources, rather than text resources in order to increase student engagement.

The importance of being able to connect from different devices was a concern brought up during the interviews. One interview participant that mentioned this talked about how connection on their phone and their laptop was important for them so that they would be able to collaborate from anywhere. We decided to make sure that we chose mobile friendly platforms that would allow the students and professors to engage in class even when they only have access to mobile devices.

Another identifiable topic that came up during the interviews was the importance of interaction in an online setting to help create incentives for the student to engage in class. One interviewee gave an example of a webinar they attended that highlighted the key points of the webinar at the beginning of the video so that those watching knew what to pay most attention to. To provide incentive at the end of the webinar a set of questions were asked based on the information, and if the questions were answered correctly the participants would receive a certificate. Another interview participant mentioned that they utilized Zoom’s polling feature as a professor to assess how a given class was progressing. This relates to an important topic: online classes can feel disconnected due to the lack of interaction that occurs for remote learning.

Overall, these interviews brought up many topics such as which remote platforms are best used for certain applications including having interactive aspects of remote learning. This data

was then utilized to provide context to the survey results, and finally when screening remote learning platforms.

Figure 2: Generated word cloud from all interview transcripts

Survey Results

From the survey results, it was clear both professors and students favored synchronous classes over asynchronous classes. Over 70% of students and 80% of professors favored synchronous classes. The percentages of each response can be seen in **Figure 3** and **Figure 4**. This could be for a variety of reasons, perhaps due to professors' desire to connect with students

(see **Figure 9)**. Having class at a scheduled time may be easier for students. However, not all classes can be taught synchronously. An asynchronous teaching solution would be better for classes when the population is spread out over various time zones, or when students live with inconsistent internet access. One interview had commented on this in particular, saying that due to poor internet connectivity, they were not able to effectively host their class synchronously.

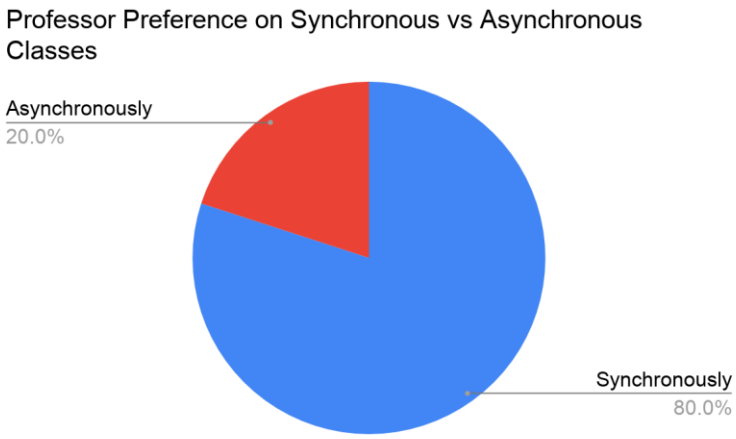

Figure 3: *Ratio of professors who prefer synchronous vs. asynchronous remote classes*

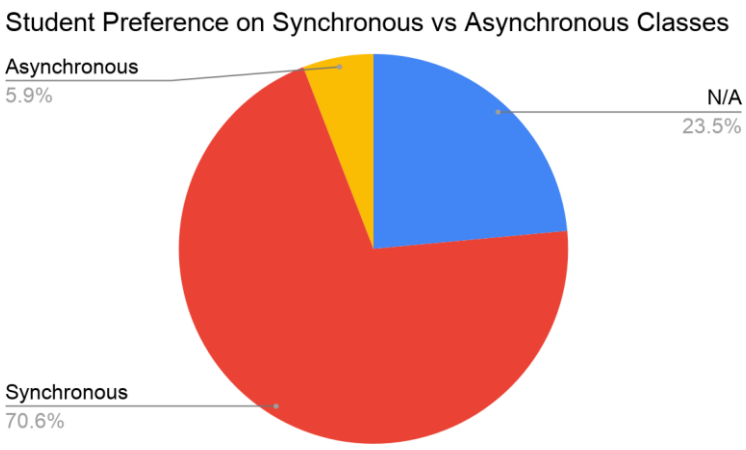

Figure 4: *Ratio of students who prefer synchronous vs. asynchronous remote classes*

In opposition to the consensus of asynchronous versus synchronous survey questions, there was no consensus between professors and students on how they rated their remote learning priorities. The survey respondents were asked to rate their view on the importance of various aspects of the remote learning experience. The only times the two groups' responses aligned were on matters relating to presentations, audio, and the ability to get help. While the two groups are not in exact agreement, **Figures 5, 6,** and **7** show that they rated these categories similarly. The most interesting deviations between the two groups were when asked to rate the importance of connection to students (peers in the case of the student survey) and the importance of having interactive responses during the lecture. As seen in **Figure 8**, professors are split on whether or not they find interactive response important, whereas in **Figure 9** they favor having a strong connection with their students. The students, on the other hand, did not find feeling a connection with their fellow classmates a priority, while they did favor interactive responses. As we talked

about in our interview findings, we inferred that when professors say they want a connection to students, they're talking about a way to tell if students have questions, or if some students are struggling with a certain topic. This requisite for student connection could be partially alleviated through the use of some form of interactive response, as talked about earlier. If professors utilized interactive response, they could get some feeling of connection to their students. This might be a welcome change for the students, given that they said that they would prefer to have interactive responses during lectures. Our survey data also suggests that professors might not need to go out of their way to create a class community between students, as students do not see it as an overall priority.

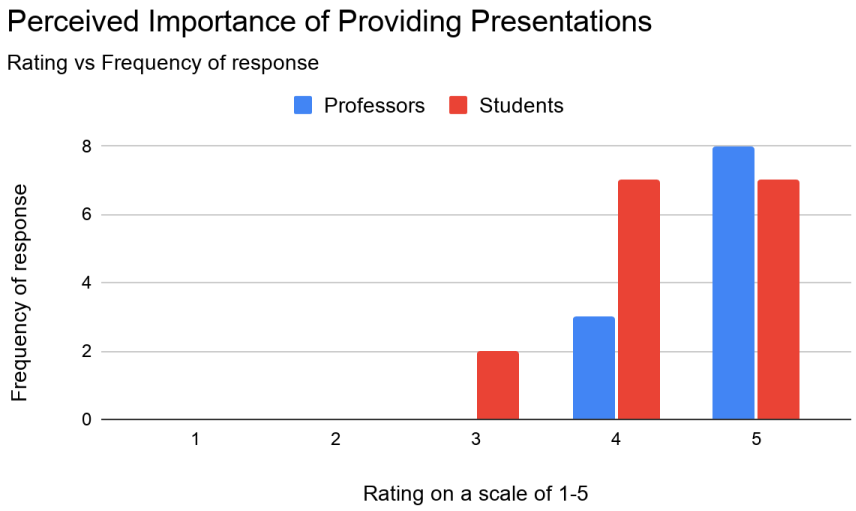

Figure 5: *Rating importance of presentations to students and professors*

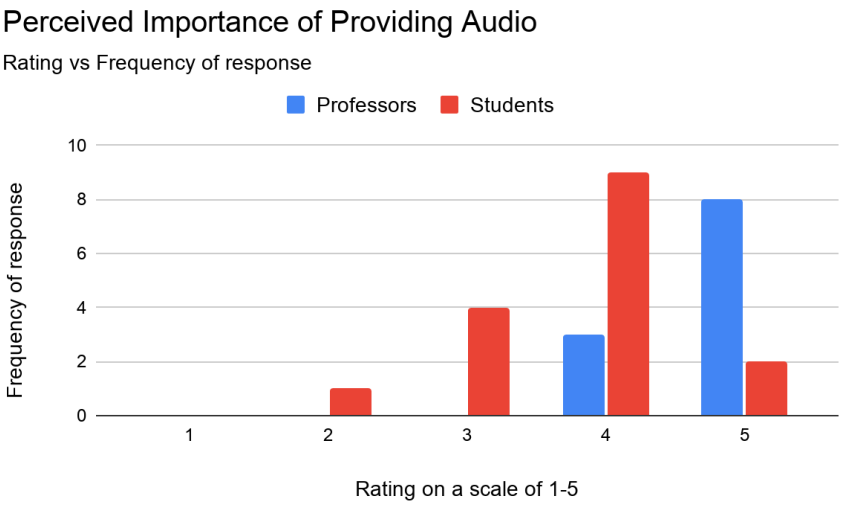

Figure 6: *Rating importance of audio to students and professors*

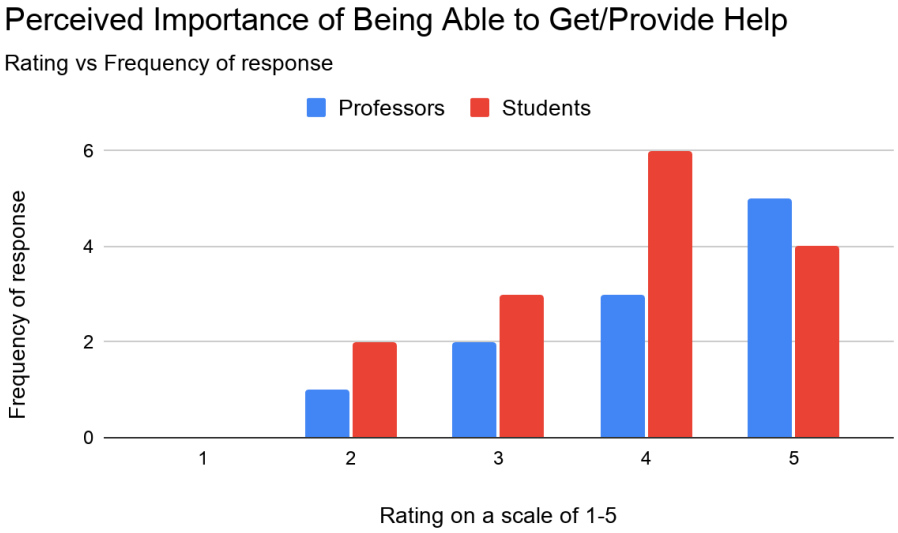

Figure 7: *Rating importance of getting/providing help to students and professors*

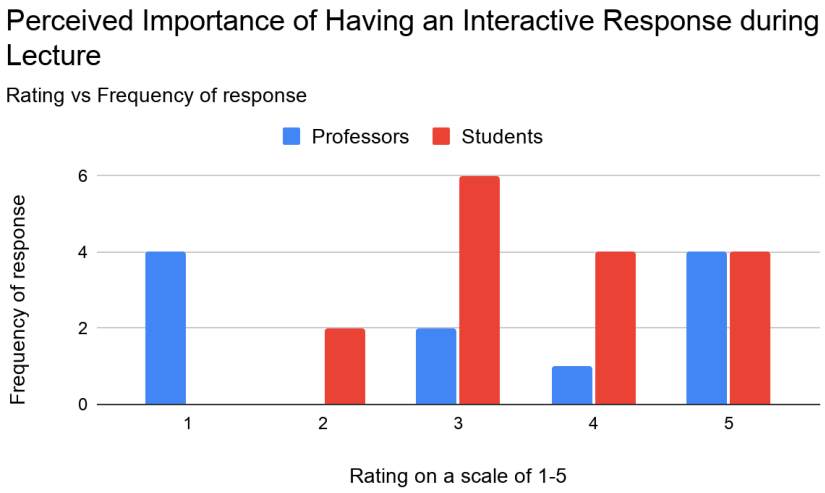

Figure 8: *Rating importance of interactive responses to students and professors*

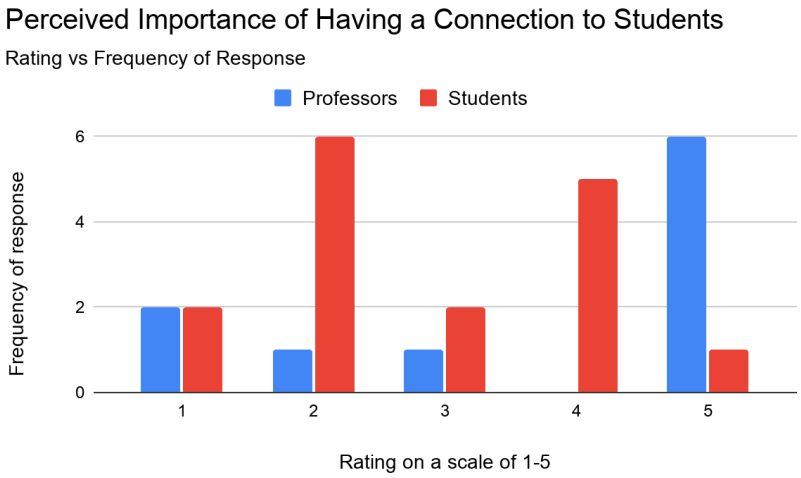

Figure 9: *Rating importance of feeling connected to students for students and professors*

Another curious result of the student survey is how much emphasis they placed on the content of learning materials. The data suggests that students value having higher quality resources than professors' preserve in remote classes. This could refer to both to resources that are better in explaining topics or digital quality (e.g. 4k video as opposed to 1080p). It is important to note that these resources include presentations that the professor may give.

In some sections, survey-takers were given the opportunity to add feedback to their previous quantitative responses. From both the student and the teacher surveys, there were insightful comments that provided context to the numerical survey results. Using the comments and the ratings together, we are able to gather context from both to get an image of what their insights into remote learning were.

One survey participant, who rated remote learning experiences as three, stated that there was "too little real-time feedback from students, [especially] the non-verbal feedback…" Using context taken from interviews, we could gather that the non-verbal feedback they were talking about was students' body-language. This was a very common remark from the surveys, with another professor commenting "the only negative point [of online teaching] in my view was the lack of direct response and reaction from the students". Even for those who had used video-based calling software, they still did not feel that they had good interaction with the students. For teachers who taught classes with labs, their issues were with the lack of lab exposure for students. One professor, who rated remote teaching a 4, mentioned that the benefit was the "flexibility of participants to be geographically somewhere else", though they said that remote learning was "not suitable for hands-on parts in teaching". Laboratory experience is a large part of our project. From our research we knew that if done right, we could assuage the lack of hands-on learning while allowing people from developing countries to still be located elsewhere.

Within the student surveys, one main theme from the comments was, as one participant commented, the “lack of social interaction” in a remote classroom setting. Some students said they feel a disconnect from others which highlights a problem that needs to be addressed in today’s online learning platforms. Another student commented that they missed the “communication between classmates”. While the survey results did not list this as an important aspect of remote classes, they did nonetheless complain about this lack of community. This may simply be the result of having to switch from an in-person class to a remote class due to COVID-19. Another issue that students brought up was internet connection. This theme was also present in two of the interviews we conducted. One survey participant said that the problems of internet connectivity were “very annoying”. A stable connection is important, because it improves real-time feedback and interaction as a whole when trying to give a video conference lecture. While this is mostly in the hands of individuals, it is an important thing to note. In developing countries, where there is not easy access to a stable internet connection, different platforms and strategies need to be utilized.

Screening Remote Learning Platforms

We used our set of criteria to start screening existing remote learning platforms to decide which ones we wanted to recommend and why. The remote learning platforms were separated by their functions for a fair comparison. We will discuss each category and the possible platforms that can be used in each case. We went through all the remote learning platforms that were suggested in interviews, surveys, and our prior research. We created a spreadsheet of each platform that we screened to conveniently view all platforms in one space. Tables 2 - 6 show the results.

We divided the online platforms into categories of their main function. These categories include: Learning Management System, Video Conference, Interactive Response, Remote Connections, and Scheduling Programs. Our final recommendation includes a choice in each category. The LMS will be the main platform with the rest of the categories acting as tools to aid the course. The video conferencing program will be used for lectures and one-on-one lab sessions. Interactive response will be used for lectures and gauging the classes' information retention. Remote connection and scheduling are to be used for the lab component of the course. Ideally, there would be a way to utilize a web app or LMS plugin to access the lab, however this would require significant additional development as there are no easy existing solutions to accessing remote labs(Mansy et al, 2020).

For developed countries, our LMS recommendation needed to include synchronous capabilities, video conferencing integration, file cloud integration, a file upload system, and have easy assessment options. All of the LMS's that had synchronous capabilities also had video conferencing integration which left us with six platforms that would still fit our needs. We found out that Edvance360 did not support file cloud integration, however the other five did. Sakai only included OneDrive and Google Drive, whereas the other 4 included Dropbox in addition to OneDrive and Google Drive. Because everyone can choose which file cloud system they want to use, we suggest using an LMS that includes all three cloud files. Moodle, Canvas, Blackboard, and D2L are all very similar and any of these have the potential to function best for remote learning. In general, we recommend that a school use one of these four options, figuring out which fits their own methodology the best. However, for OST we are inclined to recommend Moodle due to our interview data suggesting that students and professors have the most experience with Moodle. This suggests that it already fits professors' teaching style which would

warrant a smoother transition due to existing experience within the university. In our survey results, we saw that students and professors both favor synchronous learning, so Moodle is a great option to satisfy this request.

LMS:	Canvas	Blackboard	Moodle	D2L	Edvance360	Sakai	Kolibri	Rumie
Synchronous	✓	✓	✓	✓	✓	✓	✗	✗
Video Conferencing	✓	✓	✓	✓	✓	✓	✗	✗
Recordings	✓	✓	✓	✓	✓	✓	✗	✗
Chat	✓	✓	✓	✓	✓	✓	✗	✗
Cloud Integration	✓	✓	✓	✓	✗	✗	✗	✗
Mobile-friendly	✓	✓	✓	✓	✓	✓	✓	✓
Offline File System	✗	✗	✗	✗	✗	✗	✓	✓
Feedback/Testing	✓	✓	✓	✓	✓	✓	✓	✓

Table 3: *Learning management systems with features*

For our video conferencing tool, we wanted to find one with LMS integration, live whiteboard, polling, recording, and chat capabilities. From this we were able to eliminate Discord and GoToMeeting because they did not include all of our requirements. While Adobe Connect had some good features, the user interface was debilitatingly complex for what was offered, for that reason we eliminated it from our consideration. From there we were left with Zoom, BigBlueButton, and Microsoft Teams. All of these video conferencing tools have similar features, and we suggest using one of these. We then looked at the user interface for all of these tools and found that all three of these options had provided a similar user experience. For OST

we suggest using Microsoft Teams because the university already has Office 365 and using Teams would be the best option for them. This is based on a common sentiment from our survey subjects noting that they found it easier to use tools that integrated into tools they already used.

Video Conferencing:	**Zoom**	**Microsoft Teams**	**Discord**	**Adobe Connect**	**GoToMeeting**	**Cisco Webex**	**Kaltura**	**Big Blue Button**
Mobile-friendly	✓	✓	✓	✓	✓	✓	✓	✓
Recordings	✓	✓	✗	✓	✓	✓	✓	✓
Chat	✓	✓	✓	✓	✓	✓	✓	✓
WhiteBoard	✓	✓	✓	✓	✓	✓	✓	✓
Size Limit (# of People)	1000	300	50	100	250	1000	N/A	100
Breakout Rooms	✓	✓	✗	✓	✓	✓	✓	✓
LMS Integration	✓	✓	✗	✓	✗	✗	✓	✓
Simplicity	✓	✓	✓	✗	✓	✓	✓	✓
UX	1	3	4	7	5	6	N/A	2

Table 4: *Video conferencing platforms with features*

For the last three categories, interactive response, remote connection, and scheduling, we selected common platforms to compare and choose which one best fits our recommendation. Another pressing issue was that students preferred interactive responses during lectures in our surveys, and professors showed that they do not feel as connected with their students. Zoom offered interactive responses that can be used during lecture, but because we wanted a more complete learning experience platform, we opted for an additional interactive response program. To get a better picture of what options are possible for interactive response, we looked at some additional tools. For interactive response, we had the options of using Poll Everywhere, Turning

Point, and Microsoft Forms. Unfortunately, Turning Point did not include any LMS integrations. We suggested using Microsoft Forms because it included cloud integration whereas Poll Everywhere did not. This will allow professors to use their existing Office365 accounts to access and manage their forms. Having interactive response means that students can be more engaged during remote learning, and professors can gage certain aspects of their class that they might not be able to normally in a remote video lecture. The one downside of using Microsoft Forms is that it did not have as simple of an interface.

In order to interface with the refrigeration system remotely, a remote desktop connection will be the easiest method for students on and off campus. We suggest the use of the remote connection tool Splashtop. The tool offers file transfer so that students can keep their data from their session with the refrigeration system. In addition, unlike the remote desktop options that come bundled with operating systems, Splashtop is capable of connecting to computers outside of your local network. In addition, we found that Splashtop had one of the nicest user interfaces, out of the platformes screened. There are options for creating a web interface for remote laboratories, but they are outdated or do not have clear documentation on how to use them (Mansy et al, 2020). If a custom webtool is an interest, we suggest looking into the weblablib python library or the Easy Java/Javascript Simulation library. Unfortunately, only one remote desktop program allowed for scheduling, but we did not find a way to integrate the tool into an LMS, for that reason, we suggest an external scheduling tool that allows for LMS integration. For our scheduling option, we looked into Calendly, Setmore, Picktime, Outlook Calendar, and Google Calendar. We wanted to make sure it included LMS integration which left us with Setmore, Outlook, Google Calendar and Calendly. We recommend Calendly due to its easy integration into most LMS platforms. It also offers multiple features such as rescheduling,

integration into calendar apps such as Microsoft Outlook, and using a mobile device to set up scheduling. This platform also offers notifications for students to prevent them missing their time slot. We tried all options and found Setmore to be more confusing to use and expensive. We also found that while Google Calendar and Outlook Calendar provided very good general calendar solutions, they did not provide an easy service for scheduling something like a remote lab session. For this reason, we suggest Calendly as the scheduling option for lab sign-up.

Interactive Response:	**Poll Everywhere**	**Turning Point**	**Microsoft Forms**
Presentation Integration	✅	✅	✅
Mobile-friendly	✅	✅	✅
Question Types	Extensive Variation	Extensive Variation	Limited to Basic Options
LMS Integration	✅	❌	✅
Cloud Integration	❌	✅	✅
UX	1	N/A	2

Table 5: *Interactive response platforms with features*

Remote Connection:	**TeamViewer**	**ConnectWise Control**	**Windows Remote Desktop Connection**	**Splashtop**	**GoToMyPC**
Security	✅	✅	✅	✅	✅
Mobile-friendly	✅	✅	✅	✅	✅
Recordings	✅	✅	❌	✅	❌
File Transfer	✅	✅	✅	✅	✅
Price per Month	$50-$100	$35.00	$0.00	$30-$100	$66.00

UX	2	5	3	1	4

Table 6: *Remote connection platforms with features*

Scheduling:	**PickTime**	**Calendly**	**Setmore**	**Outlook Calendar**	**Google Calendar**
LMS Integration	✗	✓	✓	✓	✓
Rescheduling	✓	✓	✓	✓	✓
Integration with Calendar Apps	✗	✓	✓	✓	✓
Mobile-friendly	✓	✓	✗	✓	✓
Free Features	✓	✓	✓	✓	✓
Notifications	✓	✓	✓	✓	✓
Price per Month	$0.00	$12.00	$25.00	$3.99	$5.00
Simplicity	✓	✓	✗	✓	✓
UX	2	1	4		3

Commented [1]: UX?

Table 7: *Scheduling platforms with features*

To address how this course could be implemented in developing countries, where students may not have all the resources as OST, we have another recommendation for this case. In order to create a remote course for developing countries, a platform with strong offline capabilities eliminates the necessity of having a constant internet connection when it comes to learning. For this, we recommend Rumie. Rumie offers the ability to create courses in what they call “Bytes.” Bytes are micro courses that can be completed in under 10 minutes. Rumie claims that courses structured in this way are 20% more effective than most other learning formats. These courses need to be downloaded over an internet connection, but can then be accessed offline. Rumie also offers access to curated content available offline in the form of PDFs, MP3s,

and videos. This is important for developing countries to still learn about refrigeration systems even with a limited internet connection.

Due to the extensive features of Rumie, this eliminates the use of video conferencing, and interactive response platforms since video conferencing and interactive response platforms need a constant internet connection to use. In order to access the refrigeration system remotely, the easiest way to do that would be to use the same remote connection tool as above. Splashtop offers a way to connect to any desktop or laptop from anywhere with a smartphone or computer, as long as a basic internet connection is available. Splashtop even offers end-to-end encryption for data privacy. Students in developing countries will need to be able to have internet connection to be able to access the scheduler to schedule a lab slot, and they will need the internet while using the remote lab. We recommend Calendly as a lab appointment scheduler due to its LMS integration feature and the simplicity of using the platform.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

The overall goal and objective of this project is to devise a recommendation for OST Buchs on platforms that best suit a remote technical course for both developing and developed countries. Through interviews, survey data, and research we crafted criteria in order to screen remote learning platforms. Through screening these platforms, we were able to give a complete recommendation for OST Buchs for easy integration into a remote technical course.

Conclusions and Discussion

Our specific recommendation for OST Buchs comes in two parts, each for separate situations. The first portion of our recommendation is focused on remote classes where students live in developed countries with easy access to the internet. The second portion of our recommendation is focused on teaching classes where the majority of students live in developing countries where there is limited access to an internet connection. This presented a slight challenge, as we had to gather data for both recommendations, then do additional research for how to make a recommendation for developing countries.

Before we started our recommendation, we needed to find platforms to check through. We grew the list of platforms through the interviews, as well as a few suggestions from the survey results. For later stages of our recommendation, we found platforms using a UNESCO site that listed out learning management platforms. From this list of platforms, we built a table to compare the features.

As we began to understand how this class could be most successful, we realized that a single platform would not cover the needs of the entire course. Especially for the laboratory aspect of this project, there would have to be multiple platforms to cover all the different aspects

of the course. The recommendation on how to best teach the remote refrigeration course at OST in developed countries includes five different categories of platforms: a learning management system, a video conferencing tool, an interactive response tool, a remote desktop tool, and a scheduling tool. For a LMS we wanted to find a platform that included a file cloud system, video conferencing capabilities, and would integrate well at OST. Although there are a few platforms with all of these, our interview and survey data suggested that professors and students at OST Buchs had the most experience with Moodle. We recommend Moodle because it fits all of our criteria and experience with the platform warrants a much smoother transition, but Canvas, Blackboard and D2L would also work. Similarly, most of the video conferencing platforms included all of the features we wanted: an interactive whiteboard, conference recording, and chat functions. We recommend Microsoft Teams for OST Buchs because it has all of the desirable functions and is part of the Office 365 system that the university already has for students and professors. Since the university licenses Office 365, we also recommend Microsoft Forms as an interactive polling response. The last two categories are for the lab portion of the course and include a scheduling platform and a remote desktop recommendation. Ideally, accessing the lab would occur through a web interface that could be integrated into the LMS. Unfortunately, there are no easy ways of connecting a remote lab to the web. For this reason, we suggest using a remote desktop tool, in conjunction with a scheduling tool. However, should a web interface be desirable, we suggest looking into developing a moodle plugin using either weblablib or Easy Java/JavaScript Simulations. Those that develop the web app will have a better idea on what libraries and internal tools to use. The remote desktop recommendation is to use Splashtop, since it provides easy access to students on and off campus. Since remote desktops can only be accessed by one person at a time, there needs to be some way to schedule lab sessions. We

recommend Calendly as a lab appointment scheduler due to its LMS integration feature and the simplicity of using the platform. These platforms and tools used in conjunction with each other comprise our recommendation for OST Buch's course that will be taught in developed countries.

Creating the recommendation for developing countries was inherently different from the recommendation for developed countries. The nature of the different scenarios meant that one platform would not fit both. For classes that have students in developing countries, our recommendation was focused more on accommodating students with limited internet access time. For this situation, we narrowed our focus to LMSs with strong offline capabilities. Any programs we chose would also need to be fully compatible on mobile devices such as tablets or smartphones. We recommend using Rumie for the lecture content because it has strong offline learning capabilities and can be used on virtually any mobile device. Rumie uses videos as its primary learning tool that can be downloaded onto a device with internet connection and can then be accessed on the same device with or without internet connection. For the lab portion, an internet connection will be needed in order to access the remote desktop. Splashtop is also our recommended remote desktop for developing countries due to its ease of use, and mobile capability. This will mean that only one type of remote desktop application will have to be used on the remote lab system. These two platforms together comprise our recommendation to best teach a technical course in developing countries.

Expanded Recommendation for Other Universities:

When potentially applying the findings of this research to other universities, there are a couple of important things to keep in mind. Firstly, this recommendation is specifically for OST Buchs, and is based on some of the tools that professors and students are familiar with. Secondly, OST is a technical school, which will mean that those professors and students will have different

priorities in a remote class. Based on the research that we have done; we do have some suggestions on how you may go about finding the correct combination of platforms for your class.

If you are looking to utilize this research in a technical class that features a lab component, there are only a few considerations when applying this research. One thing that will likely change is the software used for the class. For OST Buchs, we suggested both Moodle and several Microsoft products due to the existing knowledge base. We recommend that anyone hoping to use these results at a different university look at **Tables 2** through **Table 6** to make judgments on which software to use. Another consideration when applying this research to another technical class is whether a lab is set up for remote access. In this case, OST Buchs already had a student who had constructed a remote refrigeration system that could be used in experimentation. If a school does not have this existing capability, we would suggest looking into simulation software. Unfortunately, as remote laboratories were one of the focuses of this project, we can not offer any guidance on which software to use.

We would not suggest using this recommendation in humanities courses. As the population and needs of a humanities class are significantly different from a technical class, the software that we recommend will not adequately serve such a class. Instead, we recommend that anyone hoping to use these results do research in order to determine the needs of their students and professors. This will allow them to find tools that will satisfy those needs.

It is important to remember that our findings are not universal to all schools or even all classes at a given school. In order to make the best of these findings, a professor should mold the key tenets of the recommendation to best fit his class. Regardless, we hope that this knowledge aids others in setting up a remote class.

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Appendix A: Interview Questions

Interview Questions: Professors

1. Are you comfortable with us recording this interview?
2. How long have you been teaching?
3. What is your area of expertise?
4. What is your opinion on online learning?
5. Which online teaching platform(s) have you used? Online teaching platforms meaning platforms used to teach a class purely online.
    a. If more than one, which one did you like best?
        i. Why?
6. Have you used online lab simulation platforms?
    a. Which ones?
    b. Which ones did you like best?
    c. Were there any things that made remote simulation challenging?
7. What media was used for learning modules? (audio, visual, video, etc.)
8. Was the course taught synchronously or asynchronously?
    a. If you have experience with both, which do you feel was more effective?
9. How did you evaluate the students? (quizzes, exams, etc.)
10. Have you modified an online class between years?
    a. If so, what improved student understanding?
11. Are there any features that you would like to see implemented into remote courses?

Interview Questions: Professionals

1. What is your area of expertise?
2. Have you ever had to participate in an online training program?

    a. Would you mind sharing how the program was structured?
    b. What elements of the program did you find effective or ineffective?
3. When at university, did you take any online classes?
    a. Have you used online simulation platforms for labs, experiments, etc?
        i. Which ones have you used?
        ii. Which ones did you like best?
    b. What media was used for learning modules (audio, visual, video, etc.)?
    c. What platform was used to teach you?
4. Were the training programs taught synchronously or asynchronously?
    a. If you have experience with both, which do you feel was more effective?
5. Do you have any past remote learning experiences that you would rate positively?
    a. If so, why?
6. Do you have any past remote learning experiences that you had difficulty in?
    a. If so, why?
7. How were you evaluated? (quizzes, exams, etc.)
8. Do you interact with any physical systems remotely for work purposes?
    a. If so, what are some of the difficulties that you have in working with these systems?

Interview Question: Students

1. What is your major?
2. How long have you been at university?
3. What classes have you taken online?
4. Do you prefer online classes or in person?
5. Which online learning platform(s) have you used?
    a. If more than one, which one did you like best?

        - Why?

    b. Please rate the online platforms you used on a scale from 1 to 5.

6. Have you used online simulation platforms for labs, experiments, etc?
    a. Which ones have you used?
    b. Which ones did you like best?
7. What media was used for learning modules (audio, visual, video, etc.)?
8. Was the course taught synchronously or asynchronously?
    a. If you have experience with both, which do you feel was more effective?
9. Do you have any past remote learning experiences that you would rate positively?
    a. If so, why?
10. Do you have any past remote learning experiences that you had difficulty in?
    a. If so, why?
11. How were you evaluated in your online classes (select all that apply)? (quizzes, homework, exams, etc.)
12. How do you think the online classes could have been improved?

Appendix B: Survey Questions

Survey Question: Students

1. How long have you been at university in years?
2. How many classes have you taken remotely (not including current classes)?
3. What were the circumstances behind the remote classes? (select all that apply)
4. Were those classes specific to your major or electives (Wahlfächer)? (select all that apply)
5. Rate the following from least to most important to your ability to learn in a remote setting (1 being least, 5 being most)
    a. Connection to fellow classmates
    b. Content of provided videos
    c. Content of provided texts
    d. Content of provided presentations
    e. Content of provided audio
    f. Ability to get help from course staff
    g. Quality of assessments
    h. Interactive response
6. How would you rate your best remote learning experience?
7. For your best remote learning experience, what was your biggest issue with the class?
8. Do you prefer directly taught or self-directed classes?
9. Do you prefer asynchronous classes or synchronous classes?
10. Please rate the following remote learning platforms (1 being the least effective and 5 being the most effective). If you have no opinion on the platform write N/A.
    a. Moodle/BigBlueButton
    b. Zoom
    c. Microsoft Teams

d. Whereby

e. Discord

f. Adobe Connect

g. Other (please specify)

11. If there are any remote learning platforms that have not been listed above, please list them below. If you do not have any, please leave the answer blank

12. Please describe what you liked about the remote learning platform that you rated the highest in question #10 and why you rated it that way.

Survey Questions: Professors

1. How many years have you been teaching?
2. What do you primarily teach?
3. In the last five years, how many classes have you taught remotely?
4. How would you rate the remote teaching experience? (1 being terrible, 5 being great)
5. Why did you rate the remote teaching experience the way you did?
6. Rate the following from least to most important in your ability to teach in a remote setting (1 being least important, 5 being most important)
    a. Connection to students
    b. Ease of providing videos
    c. Ease of providing text
    d. Ease of providing presentations
    e. Ease of providing audio
    f. Ability to provide help to students
    g. Ease of creating assessments
    h. Interactive response during lectures
7. Do you prefer to teach remote classes synchronously or asynchronously?

8. Please rate the following remote learning platforms (1 being the least effective and 5 being the most effective). If you have no opinion on the platform, select N/A.
    a. Moodle/BigBlueButton
    b. Zoom
    c. Microsoft Teams
    d. Whereby
    e. Discord
    f. Adobe Connect
    g. Other (please specify)
9. If there are any remote learning platforms that have not been listed above, please list them below.