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INFUSION OF SMART FACTORY INDUSTRY 4.0 LABORATORY (AMATROL STATION) IN THE MECHATRONICS PROGRAM OF CTU: THE PANDEMIC AND POST-PANDEMIC EXPERIENCE

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Abstract

The study focused on the lived experiences of BS Mechatronics students of Cebu Technological University- Main Campus the Infusion of Smart Factory Industry 4.0 Laboratory (Amatrol Station). The study utilized the phenomenological approach, precisely the hermeneutic phenomenological method of inquiry. The participants of the study were BS Mechatronics students of CTU who had undergone classes without laboratory equipment during the Pandemic and students attending classes with laboratory equipment during the gradual comeback of traditional classes. The number of participants was determined by data saturation. The study generated six (6) core themes, namely; (1) Challenges in Learning, (2) Internet (3) The Student's perspective during Implementation, (4) Laboratory, (5) Adjustment, (6) Amatrol Station. The study's extensive narrative data provided a glimpse and insights into the lives of Mechatronics students who attended classes with the Online platform and others doing a regular basis. Due to their limited financial resources, owning a device to be used in online classes is a big problem hence their learning is affected, and the internet is one of the factors that affect their learning, as well. In addition, the study disclosed that learning is a great advantage if there are tools and equipment that can be of use, as a result, it could enhance their knowledge as they can have practical activities on hand.

Keywords: *Automation, Industry 4.0, Laboratory Equipment, Mechatronics students.*

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Introduction

Educational equipment refers to the tools and resources used to facilitate learning and teaching in a formal educational setting. These tools can include physical equipment, such as laboratory apparatus and audiovisual aids, as well as software and online tools that support classroom instruction. In today's modern age, educational equipment has become increasingly important as it plays a critical role in enhancing the learning experience for students. With the advancements in technology, this equipment has become more interactive, engaging, and effective in creating a conducive learning environment for students. These varies depending on the level of education and the subject matter being taught. For instance, in science classes, equipment such as microscopes, laboratory glassware, and chemicals are used to carry out experiments, while in language classes, language learning software and online dictionaries are used to support language acquisition. [12]

The classroom needs equipment for everyone. Whether it's a test tube, a book, a pencil, or a ruler, it might be challenging to educate without the proper equipment. We would probably all like to have more specialized equipment no matter where we teach or how much we already have. (Winterbottom, 2020 January). Students' perceptions of the learning environment are an important measure of the efficacy of any educational intervention because they account for a large portion of the 20,000 hours that students spend in school from pre-school to university (Fraser, 2001).

Education is primed for technological integration, but bionic teachers are not on the horizon. If a technology is fully realized, educators and other people-centric roles that comprise a significant portion of this industry should be unaffected and have more time to perform their very human duties. The improvement of a university's facilities can serve multiple crucial purposes. One of which is educating the next generation, but educational organizations are structurally very similar to other businesses and encounter numerous challenges.

The importance of educational equipment cannot be overstated. It has become an essential tool for educators to provide high-quality instruction, enabling students to gain practical knowledge and skills to help them succeed academically and professionally. It is important for the effective delivery of educational content and for improving the learning experience of students. The absence and inadequacy of available materials can be a major concern for educational stakeholders and may stem from numerous factors.[12]

The unanticipated COVID-19 Pandemic compelled educational institutions to adopt a remote or distance-learning approach (Derasin et al., 2021). As a consequence, classes were offered online, and this shift in the mode of instruction presented significant challenges, particularly in laboratory courses (Mojica & Upmacis, 2021). In this context, it is extremely challenging for the faculty to improve the teacher-learning process or the learning transfer. Compared to the face-to-face system, the Online System of education or Distance Learning Education is significantly more prevalent.

As a requirement in the operation of a university, state- of- the-art facility and equipment is very much needed. More so that the University is offering a highly-advanced technology program, the Bachelor of Science in Mechatronics under the Automation Department. Apparently, CTU- Main Campus- particularly the Mechatronics Department has it, in possession, of the SMART FACTORY INDUSTRY 4.0 LABORATORY, specifically the Amatrol Station. This laboratory equipment is stationed and placed in one of the laboratory rooms of the

Automation Building of the University. This is a CHED Grant Equipment to the Mechatronics Program of the Automation Department of Cebu Technological University in 2019 that was intended to improve the teaching and learning of engineering and technology programs through the upgrading of facilities to produce graduates with technical skills aligned with the requirements of Industry 4.0: Mechatronics and Robotics.

Unfortunately, during the Pandemic days, this equipment has not been used for reasons that Face-to-face classes has been suspended and on- hold resorting to Online Classes. Hence, the transfer of learning is at stake and being challenged.

Methods and Materials

The study utilized the phenomenological approach, the hermeneutic phenomenological method of inquiry. The study explores the experience of Mechatronics Students of CTU during their course of study during the Pandemic and after gradually returning to regular classes, Face-to-face classes. The hermeneutic phenomenology of research is conducted through empirical (collection of experiences) and reflective (analysis of their meanings) activities. This type of research, Hermeneutic phenomenology, concerns the life world or human experience as it is lived. The focus is on revealing details and seemingly trivial aspects within the experience that may take for granted to generate a sense of knowledge and meaning (Wilson & Hutchinson,1991). Moreover, Phenomenology is essentially the study of lived experience or the life world (van Manen, 1997). Its emphasis is on the world as lived by a person, not the world or reality as something separate from the person (Valle et al., 1989).

The participants of the study are BS Mechatronics students during the Pandemic/ Online Classes and BSMX students during the gradual comeback of Face-to-Face classes. They are 3rd Year and 4th Year BS Mechatronics students who undergone classes in taking major subjects of the Program having with and without the use of laboratory equipment, the Amatrol Station. Additionally, data saturation is used in the determination of participants.

The research used the Colaizzi method to analyze the data. Colaizzi's (1978) unique seven-step process provides a rigorous analysis, with each step staying close to the data. The result was a concise yet sweeping description of the phenomenon under study, validated by the participants that created it. The method depends upon which first-person accounts of experience; these might come from face-to-face interviews but could also obtain in multiple ways; written narratives, blogs, researched diaries, and online interviews.

Ethical Consideration

Each of the twenty participants was invited to a private session by the researchers in order to uphold and to keep secure on the ethical standards in research and informed them of the study's significance. A full explanation of the research study's facts was given to each of them. It explains the purpose and framework of the study, the specifics of how and why they were selected as participants, and the potential advantages and drawbacks of participation. The informants had the right to refuse to answer any questions during the interviews if they so desired. The informants were similarly ensured that their identities are protected throughout the study using fictitious/pseudo names. Any information they revealed is treated with high respect and confidentially. In addition, the informants are assured that they can access anything they want to know about the results or findings of the study. The

participants are also given ample time to decide whether to participate in the study. The respondents signed informed consent before the interview session commences.

Results and Discussion

This part contains the materials gathered throughout an interview. Colaizzi's Method was utilized for interpreting and analyzing the gathered data. The researchers discovered the following themes based on the data collected; *(1) Challenges in Learning, (2) the Internet (3) The Student's perspective during Implementation, (4) Laboratory, (5) Adjustment, (6) Amatrol Station*

Theme 1: Challenges in Learning

This theme presents how BSMX students acquire knowledge in two different ways- during the Pandemic having online classes and during the gradual comeback of face-to-face classes.

Subtheme 1.1: Poor Learning. This subtheme presents the quality of learning gained and acquired by the BSMX students. According to informants 2, 7, 10 and 11, they gained less knowledge as they were only given online materials on their device and no hands-on experience.

> *"My learning experience during the Pandemic with the absence of actual laboratory equipment is difficult because you will learn only on knowledge but not on hands-on. I experienced PLC only using a cellphone and it is hard to understand the functions on the equipment."* ***Informant 2***

> *"With the absence of laboratory equipment, we are searching what are the specifications. How to use the equipment."* ***Informant 7***

> *"I have no learning during the Pandemic because we have no lab equipment. "****Informant 10***

In addition to the above statements, informant 11 mentioned that it is really difficult if there is no laboratory equipment.

> *"My learning experience during the course of study during the Pandemic with respect to the absence of actual laboratory equipment was difficult as a student because, from the course itself BS Mechatronics, it needs actual demonstration, actual hands-on in the equipment to learn because it is a technical course." –* ***Informant 11***

Subtheme 2.2: Lack of practical experiences. This subtheme presents the actual experiences of the informants with regard to laboratory equipment use. Informants seven (7) and eight (8) learned lessons only from videos.

> *"While learning it from the videos, it is hard to understand how it work, because you cannot see it actually."* ***Informant 7***

> *"To me as a student during the adjustment of alternative learning method or Online Classes. It is very difficult for me not to actually handle laboratory equipment since the course BSMX requires to be able to do actual manipulation on the components of a particular project."* ***Informant 8***

Additionally, another informant said how hard to learn necessary skills without the help of necessary equipment.

> *"During the Pandemic, it's hard to learn the necessary skills without the help of the necessary equipment for the learners to truly learned the subject. All I had to do during those hard time is to try to innovate an equipment that will help me visualize what the teacher teach us, me and my classmates come up with an idea that we should help and teach on what we learned and do it practically by "amot- amotan ang gamit para makabuhat ug project" and if there's something that we didn't learn on the lesson we just research and watch a tutorial about that particular lesson."* ***Informant 9***

However, informant 21 said that even using the laboratory equipment it is still hard for them to understand some of the functions of the tool as it need more careful understanding and proper guidance of an instructor.

> *"My experience during operations the machine or the Amatrol Station is lisud jud siya padaganon tapos libog sad kayo especially kung walay mo teach namo samot na sa HMI (Human Machine Interface). However, naa may teacher/ professor that helps us to understand these equipment and how to use it. Dili nami lisudan mo operate hinay- hinay. There is process sap ag learn namo sap ag operate."* ***Informant 21***

THEME 2: Internet.

This theme presents the tool that brings the knowledge into learning by the use of technological advancement, the internet.

Subtheme 3.1: Cellphones. This subtheme presents the reasons on how knowledge been acquired and learned thru the use of a gadget or device and its effect in the learning process.

> *"My learning experience during the Pandemic with the absence of actual laboratory equipment is difficult because you will learn only on knowledge but not in hands- on. I experience PLC (Programmable Logic Controller) only using cellphone and it is hard to understand the functions on the equipment."* **– *Informant 2***

Subtheme 3.2 Slow internet. This subtheme presents the effect of network provider when having an online class and how it affects students' learning. Informant one (1) and four (4) said that online classes is not clear as he is leaving in the province and that there is intermittent internet signal.

> *"It was especially hard when the internet is slow and have a low spec cellphone."* **Informant 1**

> *"It's very hard for me because wala jud klaro ang online classes and that time I'm in my province and the internet is very slow."* ***Informant 4***

Subtheme 3.3 Self-enhancement. This subtheme presents how students utilize the internet as a resource in the learning process. Informant 8 gave his view on the internet as a resource in learning more.

> *"The absence of actual laboratory equipment, my learning experience was really challenging because of the need to have knowledge about the components and equipment on a particular subject. However, because of the resources on the internet it also helps to provide knowledge and because an alternative way to learn more."* ***Informant 8***

THEME 3: The Student's perspective during Implementation

This theme presents the reasons of the informants on their views about the knowledge they need to learn from the BSMX Program and its importance on the use of laboratory equipment.

Subtheme 2.1. Practical experience. This subtheme presents the reasons on the importance of laboratory equipment as a tool to acquire knowledge. Informants 15 and 16 mentioned some of their experiences.

> *"My learning experience during the course of study with respect to the usage of laboratory equipment is an exquisite experience. We've learned to use the tools which may help me to develop skills in using the equipment currently and safely."* ***Informant 15***

> *"Through the actual usage of the equipment in our laboratories in the Mechatronics department, it is a great experience to use that equipment to use practically cause other programs in CTU didn't have the privilege to use and hands-on that equipment that we have."* ***Informant 16***

Moreover, informants thirteen and nineteen shared that actual visualization of equipment is good.

> *"During the course of study with the Amatrol System (equipment), I typically gain practical experience by physically interacting with the equipment."* ***Informant 13***

> *"My learning experience in Amatrol Station is good because I can visualize the purpose of the trainer that can be used in many industries, especially in the manufacturing industry."* ***Informant 19***

Subtheme 2.2: Great experience. This subtheme discussed how good it is when using equipment in actuality. Hence, a great experience.

According to informant twelve (12), the use of actual laboratory equipment was very constructive.

> *"My learning experience while using the laboratory equipment was very constructive. I learned about the different components and materials. We were taught to familiarize the components and their functions and how they fit into the system."* ***Informant 12***

Moreover, informant 15 adds his views that the use of laboratory equipment gives him an exquisite experience.

> *"My learning experience during the course of study with respect to the actual usage of laboratory equipment is an*

exquisite experience. We've learned to use the tools which may help us to develop skills in using the equipment correctly and safely." ***Informant 15***

THEME 4: Laboratory

This theme presents the importance and significance of the laboratory tools and equipment in the acquisition of knowledge through its usage and the effects it provides in the absence of one.

Subtheme 4.1 No access. This subtheme presents the views on the effect of not having a laboratory equipment. Informants 6 and 10 aired their take on the unavailability on the access of laboratory equipment.

"When the Pandemic strikes, it was difficult for we cannot able to actually handle any laboratory equipment." ***Informant 6***

"To be honest, it is difficult to do hands- on during the Pandemic because the laboratories are closed." ***Informant 10***

Furthermore, informant 3 emphasized the effect on the absence of laboratory equipment during the Pandemic.

"During the Pandemic I found out that I lack of knowledge, skills, devices, internet connection, relevance and issues with the system access especially of actual laboratory equipment. In addition to this many reported challenges such as poor learning space at home and lack of fieldwork and access to laboratories." ***Informant 3***

Subtheme 4.2 Familiarize devices. This subtheme presents the views on the effect of having a laboratory equipment and its impact to students in their learning process. Informants 6 and 10 aired their take on the unavailability on the access of laboratory equipment.

"We are trained and familiarized to the equipment before doing any kind of experiment. Apart from it, without having knowledge, it can be dangerous." ***Informant 15***

THEME 5: Adjustment

This theme explains the challenges experienced by the BSMX students who undergone the alternative/ flexible learning during the Pandemic where there is no actual laboratory equipment used.

Subtheme 5.1 Online Classes. This subtheme presents the student's encounter on the Online Classes done during the Pandemic. Informant 1 and 8 gave their take on this.

"It is hard because we still need to adjust to the new way of learning." ***Informant 1***

"Since the Pandemic, everything has changed including the learning system and great adjustment as well as the way of learning of students. To me as student during the adjustment of alternative learning method or Online Classes, it is very difficult for me not to actually handle laboratory equipment since the course BSMX requires to be able to do actual manipulation on the components of a particular subject." ***Informant 8***

Subtheme 5.2: Hard to Understand. This subtheme presents how students react on the alternative learning. Informants 2 and 4 presented how they manage to the adjustment of the set up.

> *"My learning experience during the Pandemic with the absence of actual laboratory equipment is difficult because you will learn only on knowledge but not in hands- on. I experience PLC (Programmable Logic Controller) only using cellphone and it is hard to understand the functions on the equipment." –* ***Informant 2***

> *"It's very hard for me because wala jud klaro ang online class. As a student, I need actual and visualize all equipment in the laboratory." –* ***Informant 4***

In addition, as stated by informants 5 and 6 said that it was not easy to learn during the Pandemic.

> *"It is not easy to learn during the Pandemic specifically the Laboratory because it needs to be hands- on and practice very well so that you can master it." –* ***Informant 5***

> *"My learning experience during the course of study especially in actual usage of laboratory equipment is difficult at first, specifically Pneumatics." –* ***Informant 6***

However, informant six (6) said that with proper teaching and many practices, I was able to learn and master it.

> *"At first it's difficult but with proper teaching and many practices I was able to learn and master it well." –* ***Informant 6***

THEME 6: The Amatrol Station

This theme presented how the AMATROL Station, the laboratory equipment used as a learning tool of the Mechatronics Department, have been very useful to BSMX students when the gradual come back of Face- to- face Classes begun. This laboratory equipment is stationed and placed in one of the laboratory rooms of the Automation Building of the University. This is a CHED Grant Equipment in 2019 intended to improve teaching and learning of engineering and technology programs to produce graduates with technical skills aligned with the requirements of Industry 4.0.

Subtheme 6.1: Operate. This subtheme presents how the students benefit the advantages of Amatrol Station laboratory equipment. Informants 14 and 20 presented how they manage to deal with the Amatrol Station set up.

> *"My learning experience during the course of study specifically the Amatrol Station is that I've learned how it works and knows how to operate and comprehend the functionality of all the components, it is more fun and interesting to learn because it is integrated with Mechanical, Electrical, sensors and how to operate with all power controls. "***Informant 14**

> *"I learn a lot from the course of study that I took, one of them is how to program microprocessors and how to trigger some*

*sensors to make them function. "**Informant 20***

According to informant eighteen, he knows how to operate with the actual using the Amatrol Station.

*"My learning experience during the course of study in actual usage of lab equipment, specially the Amatrol Station is on how it operates, the flow of the process like differentiating and organizing with the help of HMI 9Human Machine Interface), which controls the equipment". **Informant 18***

In addition, Informant twenty mentioned on how she knows the operation of the Amatrol Station including other functions.

*"I also learn how to sequence and operate the Amatrol Station and other stations that our building has. How to program the pick and place of Pneumatics robot and how to operate the SCARA (*Selective Compliance Assembly Robot Arm) and UR (Universal Robot) robot as well as programming the HMI and using the PLC*." **Informant 20***

Subtheme 6.2: Learning. This subtheme presents the views of the BSMX students on how they value the learnings of the Amatrol Station used as an instructional tool and its relevance in the field of study in the Mechatronics Program. Informants 15 and 16 gave their reasons on the use of Amatrol Station.

*"The Amatrol Station allows us to actually perform experiments rather than just read about them. Instead of taking monotonous notes, we can observe and complete exciting experiments. Such hands- on learning often makes it easier to understand challenging theories and concepts." **Informant 15***

*"As we experienced to use the Amattrol Station in our learning studies it become more effective and organized to have wiring installation and it made the equipment more organized and the use of components and sensors built- in in the Amatrol Station, can be used and accessed." **Informant 16***

As informant nineteen recollected, the use of the Amatrol Station is good because he can visualize the actual equipment and he can easily narrate in detail on his learnings regarding the use of the equipment.

"My Learning experience in Amatrol Station is good because I visualize the purpose of the trainer that can be used in many industries especially in manufacturing industry it can be pick and place, stamp and transfer to other station the product that carry and the PLC (Programmable Logic Controller) is the main brain of all the operation. Each station is having a different PLC so that the PLC is only recognized in any one station if one PLC will be used in all the operation in stamp, pick and place and

transfer the PLC." ***Informant 19***

Moreover, informant seventeen stated his learning when using the Amatrol Station.

'My learning experience during the study are the proper production process, how automation process to be maintained and the working principles of the motors. Additionally, I obtained more knowledge about sensors and actuators to be used in production." **Informant 17**

Lastly, Informant twenty reiterated on how she knows the operation of the Amatrol Station.

"Aside from programming, I also learn problem solving or troubleshooting whenever a problem or error on the said program or system occurs." ***Informant 20***

Subtheme 6.3 Application. This subtheme presents the opinions of the BSMX students on how they perceived the learnings of the Amatrol Station as an instructional tool in the Mechatronics Program. Informants 13, 14 and 16 has given their actual experience and in depth understanding on the significance on the use of Amatrol Station.

*"It's designed to simulate the real-world applications and provide practical training such as control system, Mechatronics in general and manufacturing greatly helped me advancing my knowledge. Therefore, performing tasks like setting up the station, configuring some parameters, operating controls, troubleshooting problems, and analyzing the system's operation steamed my experience to actually learned it and directly apply it in an industrial setting. "****Informant 13***

*"With this course I have so much learning that may be applied to industries. "****Informant 14***

"It can be applied also in the industry and it make more efficient and better production process that it also helps the sorting process and make the work more organized and productive." ***Informant 16***

Discussion

The study turned out that the BS Mechatronics students learn more knowledge using the Laboratory equipment, the Amatrol Station, than those BSMX students who were not able to use it during the Pandemic. There are different stories and predicaments mentioned by the students when they attended classes on an Online basis, such as the gadget they used are not as good and are low- tech, thus it is not compatible with the Apps used in the Online classes. According to Oaks & Saunders (2002), an insufficient supply and poor quality of instructional materials can create significant obstacles as teachers attempt to help students meet state-mandated content standards, pass examinations required for grade-to-grade promotion and high school graduation, and qualify for competitive opportunities in college and the workforce. Access to adequate teaching material can impact student learning opportunities as well as affect teacher self-efficacy. Researchers often ask teachers to rate their own efficacy in an attempt to understand their beliefs about specific topics (e.g., self-efficacy, motivations, etc.). Tschannen Moran and Woolfolk Hoy (2002) found that adequate

availability of teaching resources positively affects teacher efficacy.

Moreover, the study also identified various factors that basically affect the learning of students during the Pandemic, such as slow internet or intermittent internet signal, which influence the acquired learning of the students who were in Online Classes whereby they only resorted to the internet as a means of attending classes during the Pandemic. Thus, less attention on the classes at that time. In the study of Canque et. al., 2023, During the pandemic, students' internet connections suffer, making it difficult for them to participate in online discussions. Some of the most important points discussed in class could be missed on them. According to Oser (2013), classroom and school environment dimensions are significant predictors of both achievement and attitudes, even when a large number of other variables are held constant.

Another result of the study showed how a student can use state-of-the-art laboratory equipment. Based on what the students said, having to use the Amatrol Station is a very interactive and fun experience because they were able to practice technology in the real world and try it out for themselves. They also said that the experience they have gained could be used in the business when they get a job. Wells, et al. (2013) said that for students to reach their full potential with a curriculum integrated into the agricultural mechanics classroom, they need high-quality learning experiences. This means that the claims made by the BS Mechatronics students can be judged. Without good teaching materials, students may not be able to learn related skills as well as they could, and the quality of learning events may also be hurt. Correspondingly, Abojon et. al (2023) expounded that Technology-based tools and resources are essential for aiding in the development of students' technological abilities. In addition, enhancing students' technological skills is a prerequisite for improved student performance and learning outcomes. Similar to this, improved access to technical resources, the acquisition of pertinent skills, and aggressive study techniques were crucial for landing market-based positions.

This study also shows that having classes online really has a big effect on students because they have to learn how to use the new tool because they are used to having classes in person. Selvaraj et al. (2021) found in their study that both students and teachers experience some physical and mental stress. Much of this stress can be eliminated by getting used to this method and setting up classes in a way that is easy for everyone. Lack of contact between students and teachers is also a big problem for students and teachers at all levels of education. Finally, the study can shed light on the effects of Online Classes during the pandemic having the absence of Laboratory equipment used in Laboratory classes of the BS Mechatronics Program and how it can be mitigated. More so, this study can be very useful in way that it revealed that the use of the Amatrol Station has been of great help and impacted the students learning in the BS Mechatronics Program.

Conclusion

No one anticipated that the Covid-19 Pandemic would significantly alter our way of life. It took time for everyone, including the educational system, to adjust to the new norm. Without adequate training, teachers and students from all walks of life have resorted to various online collaborative tools. Despite this, they have adapted to the change in the system. As many preferred traditional learning or face-to-face classes over online classes, we can assume that this was due to the unprecedented circumstances and the instructors' and students' lack of preparation for the transition to this mode of instruction. Moreover, it is evident that the majority of instructors and students felt that regular

classes were preferable because there is actual interaction; however, we opted for online classes because it was unavoidable during the Pandemic.

Thus, the findings recommend that it is way better to do laboratory classes using the actual use of equipment, especially the Amatrol Station for the BS Mechatronics Program of the Automation Department of Cebu Technological University. As this was very useful and advantageous to students' learning, then it can be better if not best to further invest in equipment like Amatrol Station as a minimum requirement for Industry 4.0 for it can enhance students' skills and knowledge but more on their initiative to pursue an advance endeavor for the Mechatronics Program.

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