Development of an Interactive Student Module: Microchip in C Language (Phase 1)

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ABSTRACT

This research aimed to develop an online module that would revolutionize the learning motivation of students in taking highly technical subjects such as Microchip in C Language (Microcontroller Applications Laboratory) based on the Analyze–Design–Develop–Engage–Evaluate (ADDEE) framework for online module development. The research was conducted based on descriptive and developmental research designs, conforming to the Content–Interactivity–Support (CIS) design model and then implemented using the Waterfall Methodology. The module was developed in its initial phase in order to device feasible set of solutions to the identified students, teacher, technology, and institutional support challenges through the integration of various content, data, records, classroom, assessment, communication, and support management systems in an independent or blended learning approach. The module was tested to be intuitive, mobile, real time, and interactive. The respondents, composed of 28 randomly selected students of the College of Industrial Technology, Technological University Manila Campus, and 12 instructional developers, evaluated the system and found out that it was functionally suitable (x=3.57), reliable (x=3.09), operable (x=3.91), performance–wise efficient (x =4.11), secured (x=2.99), compatible (x=3.55), maintainable (x=3.41), and transferable (x=3.99) based on the ISO 25010:2011 Evaluation System, hence, it significantly contributed to the level of achievement of the students based on their semifinal and final exam scores [t_1(13)=–962, p_1=0.011; t_2(13)=–.3129; p_2=0.008]. The study further recommended its continuation to Phase 2 through the utilization of dedicated online database, high–level security layer

systems, and Applications Program Interface (API) in unifying all its modules to a single platform.

Introduction

In the past years, traditional education (face–to–face or in–class discussion) has shifted tremendously to Technology Enhanced Learning (TEL) also known as online education or e–learning, an intensive application of the Internet as a new delivery medium for educational purposes (Dichey et al., 2013).

Online education is recognized as an emerging and effective mode of teaching and learning, and is considered as one of the fastest growing trends in gaining access to education (Kibria, 2014), in the local and international perspectives. In 2009, the World Future Society predicted that virtual education is one of the breakthrough technologies that will revolutionize how, where, and when people learn, which will enter the mainstream use by 2015 and be around for over 20 to 30 years thereafter (Halal, 2006).

In the Philippines, although online learning is still an emerging market and most of its users represent only a small segment of the education and business communities (Arimbuyutan et al., 2007), the high regard for better quality education among Filipinos can be manifested on various government programs and policies that promote online learning into curriculum development. Online learning is one of the process goals of the K to 12 Program (DepEd, 2012), a qualitative assessment strategy of the Outcomes Based Education (OBE) (CHED, 2014), and a mode of delivery policy of the Association of South East Asian Nations (ASEAN) Integration's Open Distance Learning Act (RA 10650) (Republic of the Philippines 16th Congress, 2014).

Online learning modules have become essential tools for instructors to engage students and provide electronically supported learning opportunities (Commonwealth of Pennsylvania, 2014). Being student–centered, the strengths of online modules include (1) flexibility, where students learn at their own pacing (Posinasetti, 2014); (2) full participation of students, where in time and place constraints are removed (Evans & Fan, 2002); (3) depth of reflection, where learners have more time to carefully consider and provide evidence for their claims (Mikulecky, 1998; Benbunan–Fich & Hiltz, 1999) while introvert students can improve their performance levels in explaining their point of views (Shaba, 2000).

Despite those identified strengths, however, there seems to be a number of challenges among educators and instructional designers in developing online modules due to some reasons. Halal (2006) stressed out that only 10% of higher education is conducted online for the reason that instructors resist changes in their traditional methods. The latter feels that it is harder to convey their lessons virtually, which can be attributed to their level of preparation and enthusiasm (Raymond, 2000), and most significantly due to the weak course content considered for online module development (Russo, 2001).

Alexander (2001) further revealed that there are various reasons that hinder faculty in developing online modules such as (1) lack of available time—78% of lecturers claimed that developing an online course involved more time and effort than initially anticipated; (2) insufficient access to advice and technical expertise; and (3) lack of knowledge and skills requirements such as troubleshooting tasks (Volery & Lord, 2000).

In terms of students–learning–related factors, Posinasetti (2014) explained that online learning modules tend to make students feel isolated from the instructor and classmates, particularly if the instructor is not available online for help, thereby, limiting the students particularly those with low motivation or bad study habits to fall behind. Furthermore, inefficient management of online modules may result to some adverse effects on the students' behavioral patterns. Mikulecky (1998) revealed that online modules may affect (1) the spontaneity of learners; (2) increase procrastination (Benbunan–Fich & Hiltz, 1999); (3) may lessen the students' sense of connection, thus making online modules as impersonal, causing lower satisfaction level in the process (Haytko, 2001); and lastly (4) online modules have high susceptibility of online fraud and cheating such as acts of plagiarism, using concealed notes to cheat on tests, exchanging work with other students, buying instructional outputs or in some extreme and notorious cases, asking others to sit in online examinations (Bell & Federman, 2013).

Moreover, there are also technology infrastructure related factors that may possibly hinder the students to have access to online modules, such as the need for fast computers, modem, or telephone line for Internet connection, which may not be available to everyone (Uhlig, 2002). Kruse (2001) characterized that low income learners may not afford to have access to online modules particularly with communications costs and technical problems, thereby affecting their performance levels, which at worst may cause them to drop out (Bell & Federman, 2013).

In terms of institutional related factors, the cost–effectiveness of online modules remains largely an open question (Bell & Federman, 2013). Bacow et al. (2012) found out that relatively few institutions believe that online modules reduce their costs, and, in fact, most believe that online courses are at least as expensive as traditional courses based on start–up costs such as technology infrastructure, course design, training of instructors, and recurring costs, which all result to increased coordination demands and technical support. Allen and Seaman (2011) surprisingly revealed that there is little to no single approach being taken by institutions in providing training for their teaching faculty, whereas they believe that operating costs of online modules usually exceed revenues, hence, they are unsustainable to pursue further (Halal, 2006).

Nevertheless, in pursuit of the good educational aims of online learning, there are various frameworks used as basis for development of online modules by instructional designers. These frameworks are leveraged opportunities that aim to produce solutions to the above–mentioned challenges. Such frameworks are not limited to the classic (1) Analyze–Design–Develop–Implement–Evaluate (ADDIE) Model (Morrison, 2013), (2) Dick, Carey and Carey Model (Dick, Carey, and Carey, 2005), (3) Instructional Design Model for Online Learning (Siragusa et al., 2005), (4) Rapid Instructional Design (Meier, 2000), and (5) Content–Immersion–Interactivity–Communication Model (Kozlowski & Bell, 2007).

On the other hand, however, these frameworks also have drawbacks in which according to some critics they are rigid, cumbersome, driven by predetermined objectives, thus incompatible with learner–oriented objectives. They are also instructor–focused, and assume that the learner is a consumer of content and materials, and not active in the learning process (Morrison, 2013). Moreover, highly technical subjects such as Microcontroller Applications, which are normally conducted through laboratory setup, are also difficult to facilitate using online modules (Posinasetti, 2014) and there seems to be no single framework that best work for this set up. With that being said, it is up to the teacher if he should conduct lectures or instructions in traditional (face–to–face), fully independent, or blended learning approaches.

Technology by itself does not have the power to improve learning, but when utilized in online learning in combination with instruction that addresses the cognitive and social processes of knowledge construction, it can offer more diverse and effective learning opportunities than face–to–face counterparts (Dichey et al., 2013). It is true that online education has such a potential value on the holistic learning environment of students; however, the preceding challenges pose a significant obstacle among instructors, thereby fuzzing skepticism. Nonetheless, this study aimed to revolutionize the learning motivation of students in taking highly technical subjects such as Microchip in C Language through the integration of various online platforms, which help to improve the teaching and learning experiences through technology solutions, thereby answering point by point the identified challenges of this research.

Purpose of the Research

This research generally aimed to develop an interactive student module for Microchip in C Language subject. Specifically, the researcher intended to:

1. Identify the existence of laboratory class challenges related to:
    a. Students
    b. Teacher
    c. Technology
    d. Institutional Support
2. Design an online learning module based on the Analyze–Design–Develop–Engage–Evaluate (ADDEE) Framework by employing recommended solutions that answer students–related, faculty–related, technology–related, and institutional– related challenges in an independent or blended learning approach.
3. Develop the system using Waterfall Methodology with the Content–Interactivity–Support (CIS) as a guide model in integrating content, data, records, classroom, assessment, communication, and support management systems into a unified platform.
4. Test the interactivity of the system in terms of intuitiveness, mobility, and timeliness.
5. Evaluate the technical feasibility of the system based on the ISO 25010:2011 and applicability of the system based on the level of achievement of the students.

Conceptual Model

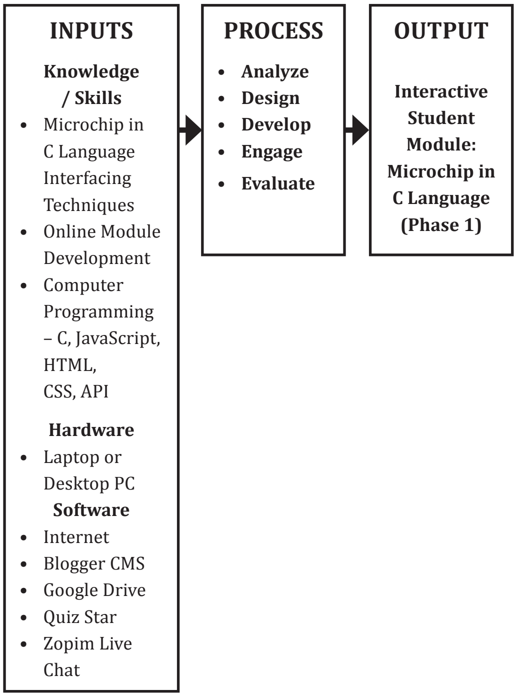

Figure 1. The IPO Conceptual Model

Illustrated on Figure 1 is the Input–Process–Output (IPO) conceptual model used in the design and development of the online module. The input variables included the (1) Knowledge and Skills Requirements such as Microchip in C Language Interfacing Techniques; Online Module Frameworks; and Computer Programming in C, JavaScript, HTML, CSS; (2) Hardware Requirements such as Laptop or Desktop PC; and (3) Software Requirements such as Internet, Blogger CMS, Google Drive, Quiz Star, and Zopim Live Chat.

Meanwhile, the process variables included the chronological steps to ***Analyze, Design, Develop, Engage,*** and ***Evaluate*** also known as the ADDEE Framework, as shown on Figure 2, an optimized version of the classical Analyze–Design–Develop–Implement– Evaluate (ADDIE) Model for online learning applications (Morrison, 2013). Lastly, once the input and process variables were fulfilled, all these factors translated to the successful development of the Interactive Student Module in Microchip in C Language (Phase 1).

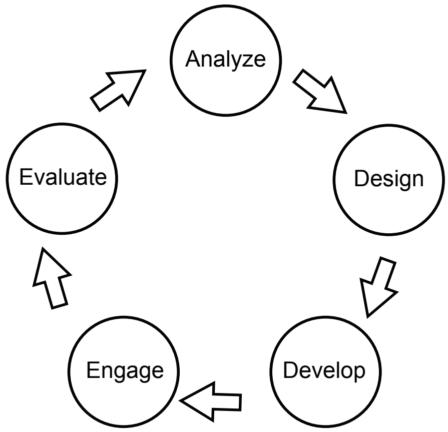

Figure 2. The Analyze–Design–Develop–Engage–Evaluate (ADDEE) Framework

Meanwhile, the modified Content–Immersion–Interactivity–Communication (CIIC) Model by Kozlowski & Bell (2007) was used as guide in ***designing*** the online module, hence, this research proposed the ***Content–Interactivity–Support (CIS) model***, shown in Figure 3, as the working design model, thereby answering the posed challenges in the laboratory class.

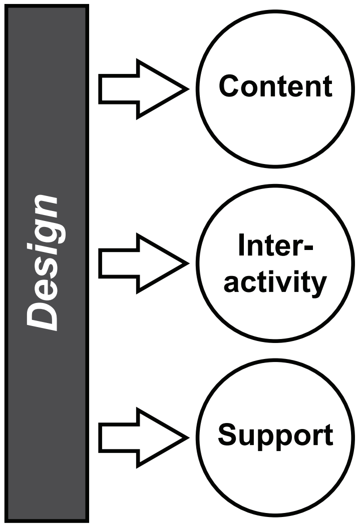

Figure 3. The CIS Model

Being an online platform in nature, the system was eventually developed based on the *Waterfall Methodology,* as shown on Figure 4. It has five major process phases such as the Requirements, Design, Implementation, Verification, and Maintenance.

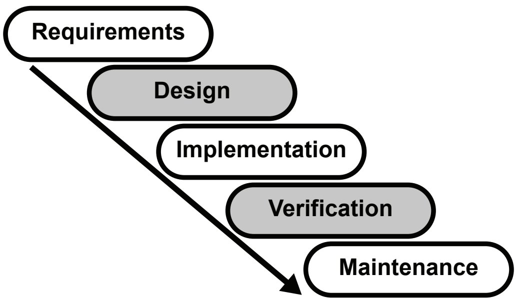

Figure 4. The Waterfall Methodology Process Model

Methodology

This study was based on descriptive and developmental research designs, for which each level has undergone several methodological steps, conforming to the Analyze–Design–Develop–Engage–Evaluate (ADDEE) framework as the main guide in developing the online learning module. The descriptive part included the determination of (1) the socio–demographic profile of the students and developers; (2) the students' perceived existence of laboratory class challenges categorized as students–related, teacher–related, technology–related, and institutional–related, (3) the developers' proposed technology solutions to the preceding challenges, and (4) the evaluation of the developed system based on its technical (4.1) feasibility and (4.2) applicability to the level of achievement of the students.

Meanwhile, the development part included the modeling, prototyping, and implementation of the online module based on the recommendation of the expert instructional developers through the utilization of Content– Interactivity–Support (CIS) Design Model, and the Waterfall Methodology for software development.

Table 1

Students' Socio–Demographic Profile

Age	*f*	*%*
16–20 years old	22	78.60
21–25 years old	5	17.90
26–30 years old	1	3.60
Total	28	100.00
Course	***f***	***%***
COET	14	50.00
ECET	14	50.00
Total	28	100.00
Academic Status	***f***	***%***
Regular	26	92.90
Irregular	2	7.10
Total	28	100.00
Family Income	***f***	***%***
<1000 PhP	3	10.70
1001–5000 PhP	5	17.90
5001–10000 PhP	8	28.60
10001–20000 PhP	5	17.90
>20000 PhP	7	25.00
Total	28	100.00
Internet at Home	***f***	***%***
None	6	21.40
Yes	22	78.60
Total	28	100.00
Computer at Home	***f***	***%***
None	4	14.29
Yes	24	85.71
Total	28	100.00
Internet at School	***f***	***%***
None	12	42.85
Yes	16	57.15
Total	28	100.00
Computer at School	***f***	***%***
None	12	42.85
Yes	16	57.15
Total	28	100.00

The respondents of this study included 28 randomly selected industrial technology students enrolled during the 2nd Semester of SY 2013–2014 of a Technological University in the Philippines (Manila), and 12 developers who specialize in instructional designs. As shown on Table 1, majority of the students are 16–20 years old (f=22; %=78.60); taking that time either Computer Engineering (COET) Technology (f=14; %=50) and Electronics Communications Engineering Technology (ECET) (f=14; %=50) course; regularly enrolled (f=26; %=92.90); with monthly family income of Php 5001 to Php 10000 (f=8; %=28.60); have Internet connection at home (f=22; %=78.60); have computers at home (f=24; %=85.71); have Internet access at school (f=16; %=57.15) and could use computers at school (f=16; %=57.15).

Moreover, as shown on Table 2, most of the developer respondents are 18–30 years old (f=8; %=66.7); specialize in Educational Technology (f=4; %=33.3) or Information Technology (f=4; %=33.3); Master's Graduate (f=3; %=25); have either <1 Year (f=4; %=33.33) or >4 Years (f=4; %=33.33) of work experience; and are earning an estimated monthly income of 10001–30000 PhP (f=5; %=41.67).

Table 2

Developers' Socio–Demographic Profile

Age	*f*	%
18–30 years old	8	66.7
31–40 years old	2	16.7
41–50 years old	2	16.7
Total	12	100.00
Specialization	***f***	**%**
Computer Engineering	1	8.33
Computer Science	1	8.33
Educational Technology	4	33.33
Information Technology	4	33.33
Others	2	16.67
Total	12	100.00
Highest Educational Attainment	***f***	**%**
College Undergraduate	2	16.67
College Graduate	2	16.67
Master's Ongoing	2	16.67
Master's Graduate	3	25.00
Doctorate Ongoing	2	16.67
Doctorate Graduate	1	8.33
Total	12	100.00
Work Experience	***f***	**%**
<1 Year	4	33.33
From 1 to 2 Years	3	25.00
From 2 to 3 Years	0	0.00
From 3 to 4 Years	1	8.33
>4 Years	4	33.33
Total	12	100.00
Income Level	***f***	**%**
<10000 PhP	3	25.00
10001–30000 PhP	5	41.67
30001–50000 PhP	3	25.00
50001–70000 PhP	1	8.33
>70000 PhP	0	0.00
Total	12	100.00

An initial ***online survey***, using Google Forms, was facilitated to both students and other developers. This survey used the chief data collection instrument, which detailed their socio–demographic profile and the trend of their perceived responses. The survey adopted a Likert's scale to categorize each degree of response, with 5 (strongly agree) being the highest and 1 (strongly disagree) as the lowest. The averaged responses were further scaled as follows: 4.51 to 5.00 as "strongly agree"; 3.51 to 4.50 as "agree"; 2.51–3.50 as "neither disagree nor agree"; 1.51 to 2.50 as "disagree"; and 1.00 to 1.50 as "strongly disagree".

All descriptive data collected were further analyzed and interpreted through the use of various statistical treatments such as mean, frequency, and paired independent t– test with 95% confidence level.

The results of the preceding descriptive analysis paved the way to the design of the system, which was conceptualized to leverage online learning experience through the integration of various solution platforms. In this study, the researcher used the *Content–Interactivity–Support (CIS)* model by categorically merging "immersion" and "communication" as sub factors of "interactivity" and added the importance of "institutional support" in the process. The CIS design concept recognized the impact of free, online knowledge management resources, instructional multimedia, intuitive user interface features, and engaging communication and support tools in the process. The extent of choosing an appropriate solution platform for student, teacher, technology, and institutional support challenges was based on the collective choice of the 12 developers, validated through online survey, live chat, and face–to–face interview. With strong background in instructional designs, the expert recommendations of the developers substantiated the relevance of integrating a specific platform as solution to each identified challenge.

After the CIS design considerations, the system was then developed based on the *Waterfall Methodology,* which has five major stages, namely, the Requirements, Design, Implementation, Verification, and Maintenance Phases. During the *Requirements Phase,* the researcher gathered pertinent information and knowledge resources needed for the development of the module; carefully planned the objectives;

and defined the scope of the project. In this stage, researching through libraries and online portals, procurement of raw materials, encoding of the lesson contents, as well as consultation with online module experts, were conducted.

During the *Design phase*, various technology solutions recommended by expert developers were highly considered, particularly those that tailor fit to the CIS Model, thereby transforming the identified problems into solutions. Texts and codes here were programmed, edited, and checked for possible typographical and grammatical errors. Designing the module was one of the most critical phases of this research, hence, its user–friendliness through simplified codes or Graphical User Interface (GUI), and portability of a wide range of web browsers were critically considered.

Meanwhile, the *Implementation phase* included the process of testing the online module to know if it would display or load the correct output, whether in personal computers or mobile devices. Bugs and errors occurred during this simulation were debugged real time. Upon successful initial testing, the respondents were given time to simulate the module on their own, allowing them to navigate through the lesson contents, answer online quizzes, and be engaged in Live Chat interaction with their instructor.

The *Verification phase* included the process of validation if necessary requirements were met by the developed system. During this phase, the module was double checked to its detailed specifications through a sequence of unit, integration, performance, and acceptance evaluation. The objective here was to ensure that the system would work and fulfill end–user satisfaction. During this phase, the instructor uploaded all lessons and quizzes online, allowing each student to learn on his own pacing, in a fully independent or blended learning style. This phase required strong expert and end–user participation in determining the system's strengths and weaknesses through satisfaction survey based on *technical feasibility,* thereby serving as basis for further improvement. Specifically, during this phase, the *ISO 25010:0211 Evaluation System* was facilitated to both students and developers to determine end–user satisfaction in terms of specific measures such as functional suitability, reliability, operability, performance, security, compatibility, maintainability, and transferability.

Lastly, the *Maintenance phase* scoped the post–development period of the online module. This phase included the continuous update of the system's graphical design to enhance visual stimulation, cross–checking of the relevance and accuracy of posted lessons and quizzes, and the enhancement of privacy settings and other features of the system like the interactivity of the embedded Live Chat, among others. Also during this stage, the researcher evaluated the *applicability* of the online module to the level of achievement of the students. This design was done by comparing the results of the face–to–face (semi–final) versus online (final) major examinations of the two groups of students in the laboratory class. Specifically, the researcher utilized a *paired independent t–test analysis* to determine if there was a significant difference on the students' level of achievement in terms of the learning discourse facilitated during those periods.

Results and Discussion

This research was conducted to develop an online module based on the ADDEE framework, featuring technology solutions that answer identified laboratory class challenges in the subject Microchip in C Language (Microcontroller Applications).

The Laboratory Class Challenges

Gleaned on Table 3 is the summary of the students' perceptions on the existence of *students–related challenges.* Interestingly, the respondents in this study "disagree" that they feel isolated in class ($\bar{x}$=2.14); they "disagree" that they feel not properly connected with their classmates and teacher ($\bar{x}$=2.29); and they "disagree" that they can ask other people to take online quiz in their behalf ($\bar{x}$=2.14); they also "neither disagree nor agree" to a certain level that they tend to procrastinate when deadlines arise ($\bar{x}$=3.21); and to the idea that they can easily cheat or find answers online ($\bar{x}$=2.75). The results of this study further revealed that the students "neither disagree nor agree" ($\bar{x}$=2.51) that certain student–related challenges exist.

Table 3
Students' Perceptions on Students–Related Challenges

Challenge	$\bar{x}$	*Interpretation*
Students feel isolated in class.	2.14	Disagree
They tend to procrastinate when deadlines arise.	3.21	Neither Disagree Nor Agree
They feel not properly connected to their classmates and teacher	2.29	Disagree
They can easily cheat or find answers online.	2.75	Neither Disagree Nor Agree
They can ask other people to take online quizzes in their behalf.	2.14	Disagree
Overall $\bar{x}$	***2.51***	***Neither Disagree Nor Agree***

In terms of *teacher–related challenges,* as summarized in Table 4, the study found out that the students also "strongly disagree" that their teacher is not highly computer literate ($\bar{x}$=1.57); they "disagree" in the idea that the teacher does not prepare well before class time ($\bar{x}$=1.68); that the teacher does not motivate the students to do great in class ($\bar{x}$=1.64); that he/she has not enough time updating the contents of the online module ($\bar{x}$=1.82); and that he/she has no enough resources in implementing online class ($\bar{x}$=1.79) and overall the students "disagree" that teacher–related challenges actually exist ($\bar{x}$=1.70).

Table 4
Students' Perceptions on Teacher--Related Challenges

Challenge	$\bar{x}$	*Interpretation*
The teacher is not highly computer literate.	1.57	Strongly Disagree
He/she does not prepare very well before class time.	1.68	Disagree
He/she does not motivate the students to do great in class.	1.64	Disagree
He/she has no enough time updating the online module contents.	1.82	Disagree
He/she has not enough resources in implementing an online class.	1.79	Disagree
Overall $\bar{x}$	***1.70***	***Disagree***

The findings further highlighted that the teacher is competitive enough to execute paper–based or online modules in class and has resources to work on with, thereby improving the learning experiences of the students. The results of this study can be validated by the fact the students–related challenges virtually may exist among them, and since the subject itself is highly technical, the teacher is persuaded to learn and improve his designing, programming, interfacing, and prototyping knowledge and skills.

The study also included the determination of the existence of *technology–related challenges,* as shown on Table 5. The results reveal that the student respondents actually "disagree" on several cases, such that they cannot use computer/laptop at home or school easily ($\bar{x}$=2.18); that there are no content, knowledge, data, or records management systems available ($\bar{x}$=2.25), and the evaluation systems implemented are not valid and reliable ($\bar{x}$=2.25).

Table 5

Students' Perceptions on Technology–Related Challenges

Challenge	*x̄*	*Interpretation*
Students cannot easily use computer/laptop at home or school.	2.18	Disagree
They have no access to fast internet connection at home or school.	2.96	Neither Disagree Nor Agree
System upgrades are not provided real time.	2.96	Neither Disagree Nor Agree
There are not enough content, knowledge, data, or records management systems available.	2.25	Disagree
The evaluation systems implemented are not valid and reliable.	2.25	Disagree
Overall x̄	***2.52***	***Neither Disagree Nor Agree***

However, the student respondents are mid–minded on the proposition that they have no access to fast Internet connection at home or school (x̄=2.96); and that system upgrades are not provided real time (x̄=2.96), hence, they "neither disagree nor agree" at certain levels or overall they "neither disagree nor agree" that technology--related challenges actually exist (x̄=2.52), which implies a greater lead for further investigation.

The last criterion investigated was the quality of *institutional support* provided for online module development. As reflected in Table 6, the students generally perceived as "neither disagree nor agree" at certain levels that the school does not advocate the implementation of online modules (x̄=2.96); administrators do not update the curriculum to be aligned to online learning (x̄=3.11); that there is no enough budget provided (x̄=3.25); that the school views the operating costs of online modules are expensive (x̄=3.14); and the school does not provide professional and technical trainings to teachers (x̄=2.82). Overall, they perceived at "neither disagree nor agree" level that the institutional support related challenges (x̄=3.06) seem quite prevalent and the students are not sure if these adversely affect their learning motivations.

Table 6

Students' Perceptions on Institutional Support–Related Challenges

Challenge	*x̄*	*Interpretation*
The school does not advocate the implementation of online modules.	2.96	Neither Disagree Nor Agree
Administrators do not update the curriculum aligned to online learning.	3.11	Neither Disagree Nor Agree
There is no enough budget provided for online module development.	3.25	Neither Disagree Nor Agree
The school views that operating costs of online modules are expensive.	3.14	Neither Disagree Nor Agree
The school does not provide professional and technical trainings to teachers.	2.82	Neither Disagree Nor Agree
Overall x̄	***3.06***	***Neither Disagree Nor Agree***

Design Considerations of the Online Module

A thorough consultation with experts sought by the researcher in order to validate the applicability of certain technology solutions to the identified challenges. In this case, 12 developers who specialize in instructional designs were surveyed and interviewed to give technical lead toward the final design composition of the online module. Specifically, the developers were asked on what extent they would agree that certain instructional solutions should be implemented to answer the prevailing students, teacher, technology, and institutional support challenges.

Table 7 details the summary of the developers' proposed solutions to the identified student–related challenges. According to them, if the students would feel isolated in class, directions and procedures should be clear and concise (x̄=4.50; agree); there should be instant communication tool (x̄=4.50; agree); and knowledge resources should be readily available (x̄=4.42; agree).

Table 7

Developers' Perceived Solutions to Students–Related Challenges

Challenge	*Solutions*	*x̄*	*Interpretation*
Students feel isolated in class.	Directions and procedures should be clear and concise.	4.5	Agree
	There should be instant communication tool.	4.5	Agree
	Knowledge resources should be readily available.	4.42	Agree
Students tend to procrastinate when deadlines arise.	There should be scheduled reminder for students.	4.33	Agree
	Lab--works should have timelines	4.58	Strongly Agree
	Rules on submission deadlines should be broadcasted.	4.17	Agree
Students feel not properly connected to their classmates or teacher.	The online module should be interactive.	4.33	Agree
	There should be a room for chat or messaging system	4.42	Agree
	Scheduled coaching should be facilitated.	4.42	Agree
Students can easily cheat or find answers online.	Online exams should be strictly facilitated.	4.33	Agree
	Exam items should be high–level and clearly stated.	4.58	Strongly Agree
	Assessment should be strictly time–bound.	4.33	Agree
Students can ask other people to take online quizzes in their behalf.	Students' authentic online identity should be established	4.42	Agree
	Online attendance should be checked real time.	4.67	Strongly Agree
	Students' web analytics should be tracked real–time.	4.67	Strongly Agree
Overall x̄		***4.44***	***Agree***

Meanwhile, if the students would tend to procrastinate when deadlines arise, then the online module should have scheduled reminder for students (x̄=4.33; agree); lab–works should have timelines (x̄=4.58; agree); and rules on submission deadlines should be broadcasted (x̄=4.17; agree). If the students would feel that they are not properly connected to their classmates and teacher, then the online module should be made interactive (x̄=4.33; agree); there should be a room chat or messaging system (x̄=4.42; agree); and scheduled coaching should be facilitated (x̄=4.42; agree). Furthermore, if the students can easily cheat or find answers online, then modular exams should be strictly facilitated (x̄=4.433; agree); exam item should be high–level and clearly stated (x̄=4.58; strongly agree); assessment should be strictly time–bound (x̄=4.33; agree). Lastly, if students could ask other people to take online quizzes on their behalf, then the online module should be able to identify the authentic identity of the students (x̄=4.42; agree); online attendance should be checked in real time (x̄=4.67; strongly agree); and their web analytics should be tracked in real–time (x̄=4.67; strongly agree).

Moreover, proposed solutions to the teacher–related challenges are further elaborated in Table 8. According to the developers, if the teacher is not highly computer literate, then he/she should be compelled to familiarize himself to the various computer languages (x̄=4.42; agree); he/she should be well–verse with various platforms and frameworks used for online module development (x̄=4.42; agree); and should have working knowledge on instructional designs or its equivalent (x̄=4.42; agree). If the teacher does not prepare very well before class time, then he/she should have a well–organized document repository (x̄=4.58; strongly agree); printed backup document should be readily available in case of Internet failure (x̄=4.67; strongly agree); and the list of lessons and syllabi should be comprehensively detailed out (x̄=4.50; agree).

Table 8

Developers' Perceived Solutions to Teacher–Related Challenges

Challenge	*Solutions*	*x̄*	*Interpretation*
The teacher is not highly computer literate.	The teacher should be familiar with various computer languages.	4.42	Agree
	He/she should be well verse with various platforms and frameworks for online module development.	4.42	Agree
	He/she should have working knowledge on instructional designs or equivalent.	4.42	Agree
The teacher does not prepare very well before class time.	He/she should have a well–organized document repository.	4.58	Strongly Agree
	Printed backup document should be readily available in case of internet failure.	4.67	Strongly Agree
	List of lessons and syllabi should be comprehensively detailed out	4.50	Agree
The teacher has hard time motivating the students.	Links to social media should be available.	4.50	Agree
	Blogs should be used for more personalized bulletin strategy.	4.33	Agree
	Real time feedback on grades and performance should be provided.	4.58	Strongly Agree
The teacher has no enough time updating the contents of the online modules.	The teacher should be reminded with to–do tasks regularly.	4.67	Strongly Agree
	He/she should have means to correct online documents real time.	4.75	Strongly Agree
	He/she should have mobile access to the online module contents.	4.75	Strongly Agree
The teacher has no enough resources in implementing an online class.	The teacher should have access to online forums or journals on online module development.	4.58	Strongly Agree
	He/she should have module contingency plan.	4.67	Agree
	He/she should have links to professional expert services.	4.42	Strongly Agree
Overall x̄		***4.55***	***Strongly Agree***

Meanwhile, if the teacher has hard time motivating the students, then he/she should provide links to social media (x̄=4.50; agree); should utilize blogs for personalized bulletin posting (x̄=4.33; agree); and real time feedback on grades and performance should be provided (x̄=4.58; strongly agree). If the teacher has insufficient time updating the contents of the online module, then he/she should be reminded with to—do tasks regularly (x̄=4.67; strongly agree); he/she should have means to correct online documents real time (x̄=4.75; strongly agree), and he/she should have mobile access to the online module contents (x̄=4.75; strongly agree). Lastly, if the teacher has insufficient resources in implementing an online class, then he/she should proactively access online forums or journals on online module development (x̄=4.58; strongly agree); should have online module contingency plan (x̄=4.67; strongly agree); and should have links to professional expert services (x̄=4.42; agree).

Table 9 further discusses the proposed solutions to address technology related challenges. The developers agreed in a certain level that if students cannot easily use computer or laptop at home or school, then there should be classroom policy on computer sharing (x̄=4.50; agree); students should be given chance to do online tasks anywhere (x̄=4.08; agree); and they should be given opportunity to collaborate tasks among themselves (x̄=4.42; agree). Meanwhile, if the students have no access to fast Internet connection at home or school, then they should be prohibited on navigating unnecessary online activities (x̄=4.58; strongly agree); should be allowed to work offline by downloading files (x̄=4.42; agree); and mobile free data should be explored for instructional purposes (x̄=4.33; agree).

Table 9

Developers' Perceived Solutions to Technology–Related Challenges

Challenge	*Solutions*	*x̄*	*Interpretation*
Students cannot easily use computer or laptop at home or school.	There should be classroom policy on ideal computer sharing.	4.50	Agree
	Students should be given chance to do online tasks anywhere.	4.08	Agree
	They should be given opportunity to collaborate on tasks.	4.42	Agree
Students have no access to fast internet connection at home or school.	Students should be prohibited on navigating with unnecessary online activity.	4.58	Strongly Agree
	They should be given chance to work offline by downloading files.	4.42	Agree
	Mobile free data should be explored for instructional purposes.	4.33	Agree
System upgrades are not provided real time.	Students should be allowed to borrow or rent updated computer facility	4.25	Agree
	Online modules should be browser--optimized.	4.50	Agree
	Online modules should be secured from malware or spyware	4.67	Strongly Agree
There are no enough knowledge, data, or records management system available	Online module should have updated knowledge–base system.	4.58	Strongly Agree
	Data and records should be securely hosted.	4.58	Strongly Agree
	The system should have engaging communication and support system.	4.67	Strongly Agree
The evaluation systems implemented are not valid and reliable.	Exams should be objective–type.	4.50	Agree
	Items should be direct and concise.	4.67	Strongly Agree
	Items should answer the objectives of the lesson.	4.75	Strongly Agree
Overall x̄		***4.50***	***Agree***

Likewise, if system upgrades are not provided in real time, then the students should be allowed to borrow or rent updated computer facility (x̄=4.25; agree); online modules should be browser–optimized (x̄=4.50; agree); and should be secured from malware or spyware (x̄=4.67; strongly agree). If there are insufficient knowledge, data, or records management system available, then online module should be integrated with an updatable knowledge–base system (x̄=4.58; strongly agree); data and records should be securely hosted (x̄=4.58; strongly agree); and the system should have engaging communication and support system (x̄=4.67; strongly agree). Lastly, if the evaluation systems implemented are not valid and reliable, then exams should be prepared as objective–type (x̄=4.50; agree); items should be directly and concisely stated (x̄=4.67; strongly agree); and items should directly answer the objectives of the lesson (x̄=4.75; strongly agree).

Table 10

Developers' Perceived Solutions to Institutional Support–Related Challenges

Challenge	*Solutions*	*x̄*	*Interpretation*
The school does not advocate implementation of online classes.	Information dissemination should be provided through online campaign.	4.50	Agree
	Social media such as group should be mobilized.	4.42	Agree
	Industrial linkages should be explored.	4.50	Agree
Administrators do not update the curriculum to be inclined with online learning.	Syllabus should be patterned with OBE curriculum.	4.67	Strongly Agree
	The teacher should be reminded on the need to update the curriculum.	4.75	Strongly Agree

There is no enough budget provided for online module development.	Free online platforms should be utilized.	4.75	Strongly Agree
	Funding through sponsors should be considered.	4.58	Strongly Agree
	The teacher should be resourceful to find alternatives.	4.75	Strongly Agree
The school views that operating costs of online modules are expensive.	Online platforms with minimal costs should be prioritized.	4.42	Agree
	Return on Investment (ROI) should be analyzed thoroughly.	4.50	Agree
	Financial feasibility study of online modules should be conducted.	4.67	Strongly Agree
The school does not provide professional and technical trainings to teachers.	The teacher should be proactive in developing instructional design skills.	4.75	Strongly Agree
	He/she should consult expert services.	4.67	Strongly Agree
	He/she should consider free online resources.	4.67	Strongly Agree
Overall $\bar{x}$		***4.61***	***Strongly Agree***

Lastly, in terms of the identified institutional support challenges, the developer-respondents perceived that certain solutions should also be implemented, as detailed in Table 10. According to them, if the school does not advocate implementation of online classes, then information dissemination should be provided through online campaign ($\bar{x}$=4.50; agree); social media group posting should be mobilized ($\bar{x}$=4.42; agree); and industrial linkages should be explored ($\bar{x}$=4.50; agree). If the administrators do not update the curriculum to be inclined with online learning, then syllabi should be patterned with OBE curriculum ($\bar{x}$=4.67; strongly agree); and the teacher should proactively update the curriculum ($\bar{x}$=4.75; strongly agree). Meanwhile, if there are insufficient budgets provided for online module development, then free online platforms should be utilized ($\bar{x}$=4.75; strongly agree); sponsorship funding should also be considered ($\bar{x}$=4.58; strongly agree); and the teacher should be resourceful to find alternatives ($\bar{x}$=4.75; strongly agree). Moreover, if the school views that operating costs of online modules are expensive, then online platforms with minimal costs should be prioritized ($\bar{x}$=4.42; agree); Return of Investment (ROI) should be analyzed thoroughly ($\bar{x}$=4.50; agree); and financial feasibility study of online modules should be conducted ($\bar{x}$=4.67; strongly agree). Lastly, if the school does not provide professional and technical trainings to teachers, then the teacher should be proactive in developing his instructional design skills ($\bar{x}$=4.75; strongly agree); he/she should consult expert services ($\bar{x}$=4.67; strongly agree); and he/she should consider free online knowledge and skills tutorials ($\bar{x}$=4.67; strongly agree).

Based on the results of the preceding survey, the developer-respondents agreed to certain levels that several measures should be implemented in order to combat students, teacher, technology, and institutional support related challenges particularly in the utilization of online modules for instruction. The developers further recommended that specific software solutions that could carry over the expected solution measures into a unified platform with necessary feature sets, conforming to the focus of the Content–Interactivity–Support Model.

Table 11 highlights the proposed module solutions that cater to the identified challenges, clustered into three (3) major areas such as *Content* that focuses on the feature set of content management, data and records management; the *Interactivity* of the system, which is delivered through a communication management system; and the *Support* functionality in terms of the utilization of appropriate assessment and classroom management systems. Content Management Systems (CMS) are software content platforms used in the design and development of either a static or dynamic website. Data and records management systems are online/offline–based repository that can store data or files primarily via cloud. CMS are integrative platforms used for interactive communication purposes, while assessment and classroom management systems are specialized support systems used to facilitate assessments such as objective–type quizzes, assignments, or major examinations.

Table 11

Developers' Proposed Online Module Solutions Based on the Content–Interactivity–Support (CIS) Model

Area	*Focus*	*Module Solutions*	*f*	*%*
Content	Content Management	Blogger	6	50.00
		Joomla	1	8.33
		Wix	1	8.33
		Wordpress	4	33.33
		Total	***12***	***100***
	Data and Records Management	Apple iCloud	1	8.33
		Drop Box	1	8.33
		Google Drive	9	75.00
		Microsoft Drive	1	8.33
		Total	***12***	***100***
Interactivity	Communication Management	Facebook Messenger	4	33.33
		Skype	1	8.33
		Yahoo Messenger	1	8.33
		Zopim Live Chat	6	50.00
		Total	***12***	***100***
Support	Assessment and Classroom Management	PollMaker	2	16.67
		Quizstar	10	83.33
		Examtime	0	0.00
		Quizbean	0	0.00
		Total	***12***	***100***

Considering the most popular solutions platforms in the Internet today, the developer respondents aggregately proposed *Blogger* (f=6; %=50) to be used for content management; *Google Drive* (f=9;%=75) for data and records management; *Zopim Live Chat* (f=6; %=50) for communication management; and *QuizStar* (f=10; %=83.33) for assessment and classroom management. The developers further validated that these platforms are proven to be highly reliable, universally compatible, very secured, and very economical (usually free), and generally have feature set solutions that answer point by point each identified challenge for online module development.

Development of the Online Module

Through the technical advisory and expert services provided by the developer respondents themselves, the researcher then initiated the development of online module by integrating Blogger, Google Drive, Zopim Live Chat, and Quizstar into a unified platform thereby expected to answer the identified challenges. These platforms were expected to deliver categorical solutions in terms of content, data, records, communication, assessment, and classroom management.

Detailed on Figure 5 is the operations flowchart based on the Waterfall Methodology for online module development. The first step was for the teacher/instructor to signup for an Internet–based email, which would be used in creating individual account to Blogger, Google Drive, Zopim Live Chat and Quizstar. For this particularly case, the researcher utilized *Google Mail,* which could be used for both Blogger and Google Drive, then eventually created individual account to Zopim, then to Quiz Star using the same email account.

As expected to a teacher/instructor, the second major step was to upload the lessons of the subject Microchip in C Language (Microcontroller Applications). In this case, the *Google Drive* was used to create, edit, upload, and store all documents, spreadsheets, and presentations needed for the subject. Each lesson file has a Uniform Resource Locator (URL), which privacy setting could be controlled whether to allow or deny a specific viewer (student) to access/edit/view the said document for security purposes. For this particular case, each lesson was configured to be "can be viewed only" option.

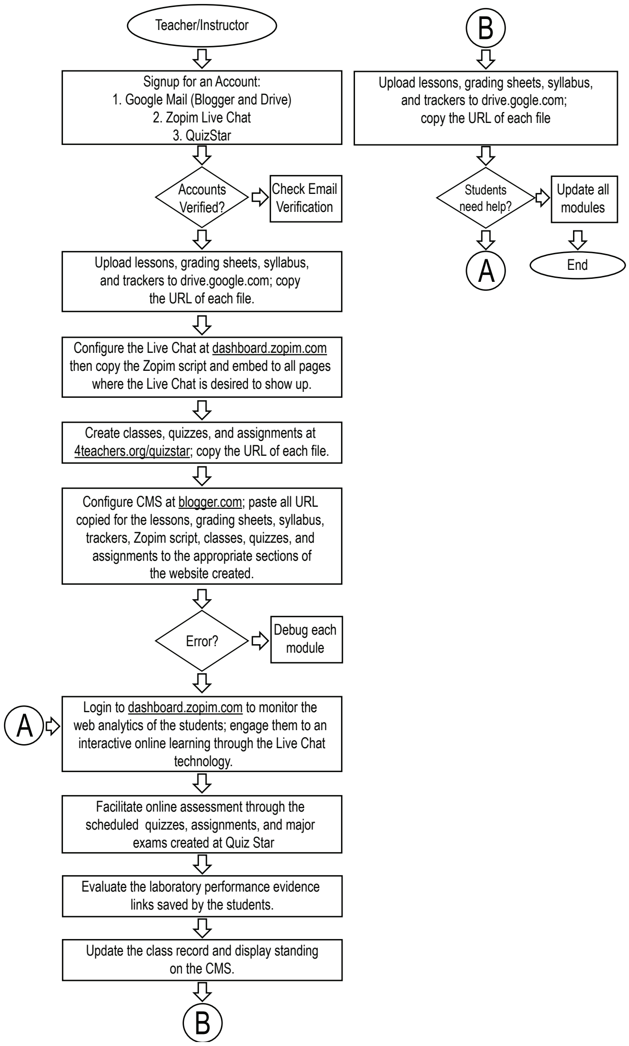

Figure 5. Online Module Development Operations Flowchart

As shown on Figure 6, the Google Drive serves as the online data and records management system of the module, in which specifically, the researcher uploaded ten *Portable Document Format (PDF)–based lessons, created two separate class record spreadsheets for COET and ECET sections, and one spreadsheet tracker* for the URL of the assignments/ seatwork (Google Drive–based) laboratory evidences (e.g. Youtube or Facebook video links) saved thereto by the students.

The third step was to configure the Live Chat in terms of color theme, text, and messages preferences so that it would match to the final design of the online module. In this case, the *Zopim Live Chat,* as shown on Figure 7 (dashboard) was used as communications management system. It has the capability to track the analytics of each student particularly on what page he is currently into, how long has been there, IP address, location, and other essential data used to identify each student online behaviors. It is a powerful communication tool used to engage each student for more meaningful learning or coaching experience. Moreover, the researcher this time copied the Zopim script on the dashboard then pasted it directly to the HTML script editor of each specific web page where the Live Chat was intended to show up.

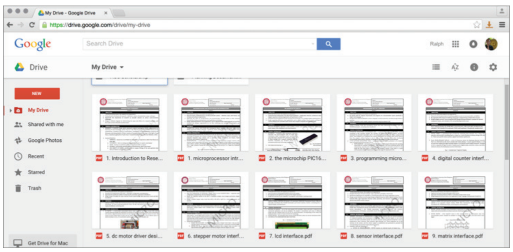

Figure 6. Data and Records Management System (drive.google.com)

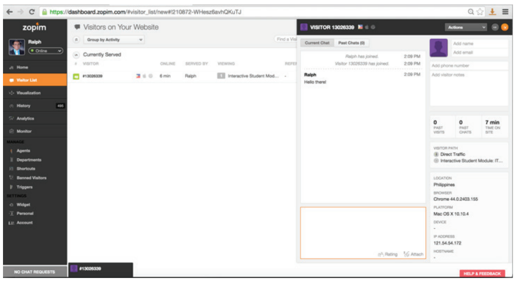

Figure 7. Communications Management System (dashboard.zopim.com)

The fourth step on the development process was to create an online class, and quizzes intended for assessment purposes of the students' performances. Specifically, the system utilized *QuizStar,* as illustrated on Figure 8. QuizStar has the capability to assign students on a specific class; strictly facilitate objective–type quizzes or major exams, which can be assigned on specific time, day, or duration. Furthermore, it can generate reports of quiz results, which can be exported to spreadsheet files for further application purposes.

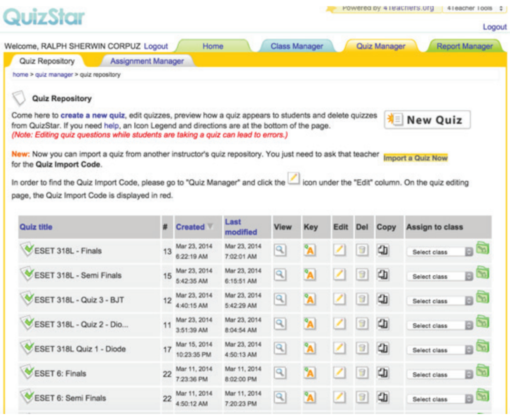

Figure 8. Assessment and Classroom Management System (4teachers.org/quizstar)

The last crucial step in developing the online module was to configure the website using a CMS. Specifically, the researcher utilized *Blogger* due to its flexibility, it is free, can be personalized, and has a wide range of applicable extension programs. The CMS controls the overall front end of the online module as seen by the students themselves. During this time, the researcher pasted all the URL of the lessons, grading sheets, syllabus, trackers, Live Chat script, classes, quizzes, and assignments to the appropriate sections of the website. The design of the website was also modified to suit to the technical background of the subject particularly on the adjustment of color scheme, text, layout, etcetera.

Figure 9. The Interactive Student Module: Microchip in C Language (rsacmicro.blogspot.com)

Highlighted in Figure 9 is the home page of the developed online module, which displays various menus and the Live Chat at the lower right section. It has the "Login" page, which collects demographic information of the user; "Labworks" page, which lists all the lessons to be taken; "Reports" page where students have to past the specific URL of each labwork evidence video; "Checkpoint", which redirects to the QuizStar; "Downloads" which summarizes all the download links and files needed for the interfacing activities of the subject; the "Class Record", which summarizes the class standing of the students in a spreadsheet; and the "Survey" used for post– qualitative user satisfaction survey.

In order to complete the entire online learning process, the students should have to create a Quizstar account while Google Mail account (for Google Drive access) is optional. Initially, the students should access the URL of the website ***rsacmicro.blogspot.com*** then click on the Live Chat button at the lower right side; then they have to complete the pre--chat form with their credentials such as name, email, and contact number. This time, they can now read the desired lesson on the "Labworks" page and should they have questions on each lesson, they can ping the teacher/instructor using the Live Chat. Meanwhile, since the subject is laboratory based in nature, the students are required to take videos of their circuit--making, prototyping, programming, and interfacing activities for documentary purposes. The links of the videos through YouTube or Facebook, should be pasted on the "Reports" page where the tracker for labwork evidence report is located. Moreover, if the students are to take an online quiz, assignment, or exam, they should click on "Checkpoint", which details out further instructions on finding the "correct online class" thereby redirecting them to the Quizstar "class" created by the teacher/instructor.

The Interactivity Test Results

The interactivity of the developed online module was one the most crucial factors considered by the researcher, whereas, a small group of developers and sample student respondents validated its performance based on the system's intuitiveness or usability indicated by its efficiency; mobility in terms of web and mobile browsers compatibility; timeliness measured in its seconds of loading duration; and the overall interactivity of the system based on user satisfaction as detailed out further on Table 12.

Table 12
Interactivity Test Results

Factor	*Metric*	*Blogger*	*Zopim*	*Google Drive*	*Quizstar*	*Results*
Intuitiveness (Usability)	Efficiency	No Errors	No Errors	No Errors	1 Error*	Passed
Mobility	Web	Yes	Yes	Yes	Yes	Passed
	Mobile	Yes	Yes	Yes	Not Optimized	Passed
Timeliness	Load Time(s)	0.5	0.89	0.65	1.25	Passed
Interactivity	User Satisfaction	Interactive	Very Interactive	Interactive	Interactive	Passed

**–Student encountered error due to Internet connectivity failure*

With 3 averaged trials per metric measured, the results revealed that the modules of the system recorded no errors except for the QuizStar page where the student encountered an Internet connectivity failure during one trial. All the modules were also tested to be compatible with both web and mobile browsers since they have their specialized mobile app versions, except for the QuizStar. Meanwhile, in terms of loading time, the Blogger takes approximately 0.5 s to load each page; 0.89 s to navigate through the Zopim dashboard menus; 0.65 s for the Google Drive to display each file (e.g. lesson); and 1.25 s for the QuizStar to lead each page of a quiz, respectively. Lastly, in terms of the overall interactivity of the system, the developers and sample students agreed that all modules were interactive while the Zopim Live Chat as very interactive. Overall, the online module has successfully completed and passed all testing measures conducted, hence, the system has been validated to be technically interactive.

Evaluation Results of the Online Module

Any developed software should establish a sound acceptability to its end- - users; hence, this research facilitated the ISO 25010:2011 evaluation system to 28 COET and ECET students, and 12 developers who specialize in instructional designs. The survey aimed to qualitatively validate the technical feasibility of the system in terms of functional suitability, reliability, operability, performance efficiency, security, compatibility, maintainability, and transferability.

As shown on Table 13, the respondents were "satisfied" in terms of its functional suitability ($\bar{x}$=3.57); operability ($\bar{x}$=3.91); performance efficiency ($\bar{x}$=4.11); compatibility ($\bar{x}$=3.55); and transferability ($\bar{x}$=3.99). On the other hand, however, the respondents were "neither satisfied nor unsatisfied" on the outcomes of the system in terms of reliability ($\bar{x}$=3.09); security ($\bar{x}$=2.99); and maintainability ($\bar{x}$=3.41), which such results could be attributed to the fact that the system is relatively new and its modules are independently hosted by their respective providers according to the developers. Nevertheless, the respondents were overall "satisfied" ($\bar{x}$=3.58) with the outcomes of the online module after its initial phase of development.

Table 13

ISO 25010:2011 Evaluation Results

Factor	*Metric*	*x̄*	*Interpretation*
Functional Suitability	Suitability	3.63	Satisfied
	Accuracy	3.54	Satisfied
	Interoperability	3.54	Satisfied
	x̄	3.57	Satisfied
Reliability	Maturity	2.89	Neither Unsatisfied Nor Satisfied
	Fault Tolerance	2.90	Neither Unsatisfied Nor Satisfied
	Recoverability	2.88	Neither Unsatisfied Nor Satisfied
	Compliance	3.20	Neither Unsatisfied Nor Satisfied
	x̄	3.09	Neither Unsatisfied Nor Satisfied
Operability	Appropriateness	3.67	Satisfied
	Recognize ability	4.20	Satisfied
	Ease of Use	4.54	Very Satisfied
	Learnability	4.55	Very Satisfied
	Attractiveness	3.53	Satisfied
	Technical Accessibility	2.98	Neither Unsatisfied Nor Satisfied
	x̄	3.91	Satisfied
Performance Efficiency	Time Behavior	3.66	Satisfied
	Resource Utilization	4.55	Very Satisfied
	x̄	4.11	Satisfied
Security	Confidentiality	2.67	Neither Unsatisfied Nor Satisfied
	Integrity	3.55	Satisfied
	Non--repudiation	3.62	Satisfied
	Accountability	2.56	Neither Unsatisfied Nor Satisfied
	Authenticity	2.55	Neither Unsatisfied Nor Satisfied
	x̄	2.99	Neither Unsatisfied Nor Satisfied
Compatibility	Replace ability	3.54	Satisfied
	Co--existence	3.55	Satisfied
	x̄	3.55	Satisfied
Maintainability	Modularity	3.23	Neither Unsatisfied Nor Satisfied
	Reusability	3.12	Neither Unsatisfied Nor Satisfied
	Analyzability	3.61	Satisfied
	Changeability	3.89	Satisfied
	Modification Stability	3.04	Neither Unsatisfied Nor Satisfied
	Testability	3.57	Satisfied
	x̄	3.41	Neither Unsatisfied Nor Satisfied
Transferability	Portability	3.89	Satisfied
	Adaptability	4.52	Very Satisfied
	Install ability	3.55	Satisfied
	x̄	3.99	Satisfied
Overall x̄		***3.58***	***Satisfied***

Legend:
4.51 – 5.00 – Very Satisfied
3.51 – 4.50–Satisfied
2.51 – 3.50 – Neither Satisfied Nor Unsatisfied
1.51 – 2.50 – Unsatisfied
1.00 – 1.50 – Very Unsatisfied

Table 14

Paired Independent T–Test Results on the Students Level of Achievement

	Mean	*Std. Deviation*	*Std. Error Mean*	*95% Confidence Interval of the Difference*		*t*	*df*	*Sig. (2–tailed)*
				Lower	*Upper*			
ECET	-2.714	3.429	0.916	-4.694	-0.734	-2.962	13	0.011
COET	-3.929	4.698	1.256	-6.641	-1.216	-3.129	13	0.008

Another important objective of this research was to evaluate the applicability of the developed system to the students' level of achievement. In order to achieve this purpose, the researcher conducted a comparative strategy on determining the performance of two group of students composed of 14 Computer Engineering Technology (COET) and 14 Electronics and Communications Engineering Technology (ECET) students to validate if one result can replicate the other. The foregoing Table 14 shows the paired independent T–test results of the level of achievement of the two groups of students (COET and ECET) with Semifinals (face–to–face assessment) and Finals (online exams) as validators. The $t(13)=-2.962$, $p=0.011$; and $t(13)=-3.129$; $p=0.008$ values imply that there was a significant difference between the semifinals and final exam scores of both ECET and COET Students, hence, the utilization of online module significantly improved the level of achievements among the students.

Conclusion and Recommendations

Based on the salient results of data analysis and interpretation, the study found out that the students were technically capable in utilizing online learning module at home or school. Moreover, the study revealed that the students and their teacher seemed to have no problems with the utilization of online module in a laboratory class, such as Microchip in C Language (Microcontroller Applications), but were unsure at what extent student, technology, and institutional support challenges would affect their teaching and learning outcomes.

The utilization of the Analyze–Design–Develop–Engage–Evaluate (ADDEE) Framework was very effective guide in resolving students–related, teacher–related, technology–related, and institutional support challenges encountered in the laboratory class. In which, specifically, the implementation of Content–Interactivity–Support (CIS) Model, the Waterfall Methodology, and the consultation to the expert instructional developers were very helpful in devising feasible set of technology solutions through the integration of various content, data, records, classroom, assessment, communication, and support management systems in an independent or blended learning approach.

The developed platform was tested to be intuitive, mobile, real time, and overall interactive. The respondents further evaluated the system to be functionally suitable, reliable, operable, performance–wise efficient, secured, compatible, maintainable, and transferable, hence, it significantly contributed to the level of achievement of the students based on the statistical results.

The researcher proposed to pursue the development on its Phase 2 through the utilization of dedicated online database, subscription to high–level security layer system that reinforces confidentiality of data, and the use of Applications Program Interface (API) in unifying the individual module to a single platform.

■ ■ ■

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