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Administering Online Environment Pedagogies for Science and Technology Undergraduate Students under COVID-19 Pandemic

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Abstract

This article establishes an online environment planning and management for science and technology instruction that can be carried out as effective as off-line learning in Thailand. An undergraduate online environmental model is devised alongside the off-line counterpart to compare their viability from the corresponding environmental aspects. Four administrative factors, namely, number of students per section, subjects taken, assignments, and frequency of students' participations are employed as the bases for determining the optimal class size that is suitable for online environment planning with the help of the well-established Linear Programming technique. We find that financial support on training, equipment, network and infrastructure to institution, instructors, students, and out-of-school connectivity are the critical success factors for a fruitful online environment in the COVID-19 pandemic and beyond. In addition, some student's behavior, study preparation, and attitude are also revealed. The psychological impacts on student's life are utmost important that the university must heed. Consequently, administration must not emphasize too much on study results and overlook this human aspect.

Keywords: *COVID-19, Digitization, Online Learning, Wet/Dry Laboratory, Out-Of-School Connectivity.*

INTRODUCTION

The disruption of COVID-19 pandemic changes almost everything in life and our future living. Lifestyle will never be the same in all respects from personal matter, daily life, family living, education, philosophy of socialization, governmental policy, and international way of working. In this article, we will focus on one important facet that is greatly affected by this disruption. It is education. Before COVID-19 pandemic, classroom (or on-site, face-to-face, off-line, all of which will be used interchangeably in this article) lecturing is a widely practiced form of traditional education by educators everywhere. Despite the advent of educational innovations such as online, distance learning, modular lessons, self-studied instructions, they only serve as alternative or supplementary forms of studies. The good old classroom lecturing format remains to be the mainstay. However, one shortcoming that hampers this practice is underfunding of educational and technological infrastructures (Bunescu et al. 2021). The disruption of COVID-19 pandemic has revolutionized and accelerated digitization of education. Distance learning has received more attention to improve the education systems which include teachers, pupils, staffs, and relating services. The central focus is undoubtedly a new curriculum that must fit this new learning format, encompassing the Web, online connection via hardware and software, learning materials, and teaching methods. Issues for preparation of online/distance learning are digital content and technology (Burns 2011), structure of online class (Muthuprasad et al. 2021), communication requirements, support (Burns 2011), quality of teachers and teaching process (Gopal et al. 2021), and student's perspective, experiences, and attention (Blackmon et al. 2012).

The study will focus on two issues: class size or instructional workload and human aspect of student online learning in science and technology undergraduate student of Thailand. Factors of curriculum management that must tailor online learning to accommodate the COVID-19 pandemic situation are numerous. Due to the unprecedented COVID-19 situation which has never happened in human history, there are virtually little good sources of reference to use in this epidemic situation.

The context of this study and execution focus on undergraduate curriculum to fit our education and budget during the academic year 2018-2020, i.e., courses are enumerated by credit-hour/week per semester. There are 15 weeks per semester. Table 1 shows the study load required on the student's part for each conventional

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semester class. For example, an undergraduate 3-credit hour lecture class, denoted by #credit(lecture-lab-self-study) or 3(3-0-6) numerically requires that the student must spend 3 hours in-class lecture, 0 hour lab work, and 6 hours self-study, respectively, for a total of 9 hours per week to obtain three credit-hour of study. Similarly, the same 3-hour lecture with lab class such as 3(2-2-5) requires 2 hours in-class lecture, 2 hours lab work, and 5 hours self-study, respectively, for the same total of 9 hours per week. This current class environmental configuration must be rearranged to accommodate a "new normal" online learning under COVID-19. There are five proposed environmental forms to choose that are mandated by the Ministry of Higher Education, Science, Research and Innovation, namely, on-site, online, on-hand, on-air, and on-demand. A few proposed combinations in the form of online:on-site ranging from 15:0, 12: 3, or 10:5 have been tried, that is, 15 weeks online to 0 weeks on-site, 12 weeks online to 3 weeks on-site, or 10 weeks online to 5 weeks on-site, respectively. The last two choices are set up to accommodate on-site lab work (wet lab) if it is not possible to omit or replace them by online lab (dry lab) demonstration. Due to the severity of the pandemic with complete lockdown, this study will focus on science and technology (S&T) classes that fit the first choice.

Table 1. Study load (in hours) required for each class category

Category	Loading	Total hour	Explanation
Lecture	3(3-0-6)	credit x 3	regular study load that an undergraduate student must spend, i.e, N1(N2-N3-N4), for a total of N1 x 3 = (N2+N3+N4), e.g., 4(3-2-7) expands to 4x3 = (3+2+7).
	4(3-2-7)		
	1(0-0-3)		
Laboratory	1(0-2-1)		
Senior project	1(1-0-2)		project proposal takes 1 credit-hour; project work takes 2 credit-hour.
	2(2-0-4)		
Seminar	1(1-0-2)		
Individual study	3(0-0-9)		

N1: number of credit-hour, N2: hours of in-class lecture, N3: hours of lab work, N4: hours of self-study

Careful considerations of this ratio are placed on individual subject contents, instructor, students, and available resources. After two semesters of 15:0 teaching, we have come to some first-hand conclusions on these issues as follow:

Subject contents. The contents of current curriculum fare well, but the way of presentation to attract students' attention is a challenge. Unlike on-site teaching where additional instructor's gesture, demonstration, and verbal and written explanations on the blackboard can be improvised and intermixed to supplement the lecture, the online way of teaching is different. The fact that it is technology dependent makes it difficult to prepare this online teaching process digitally and substitute face-to-face instruction (Advance IT Minnesota 2016). Consequently, student's performance assessment is difficult to prepare, set up, and evaluate.

Instructor. The technical skill and maneuverability of modern technological gadgets are the most important know-how with which the instructor must keep pace to conduct and assess the online class effectively and efficiently. This requires training and proper technical support since different hardware and software work differently for content presentation. They provide different administrative functions to support the course contents such as class roster, quizzes/tests, homework, group projects, examinations, and grading procedures. These add up enormous workload for the instructor.

Student. One important issue pertaining to students' learning is their attention. The lack of face-to-face interaction reduces learning attention considerably. Delayed feedback or help due to teacher's availability when the students need might be attributive to decrease in their motivation to participate in the online class, and eventually to attend it. Other socio-economic factors such as lack of peer presence, improper or unable to resort the needed devices and configuration to run the online session, balance between education and life (that leads to skipping the online class for extra jobs), etc., hamper a fruitful outcome of students' online learning.

Resources. The lack of proper resources to access and run the online class is also one overlooked factor that the institution must heed. Expenses ranging from internet fees, internet connecting devices, software, and electricity charges are elements that many student's families cannot afford. Instructors in developing countries are no exception.

The above considerations require large-scale improvement and financial support to keep the education system running properly during the COVID-19 lockdown and the aftermath of the pandemic. From experience of the past two semesters, we resorted to some reasonable solutions that could handle few of the above obstacles with available resources and efforts for online environment planning and management, having some benefits from out-of-school connectivity. This leads to the objectives of this study, namely, (1) proper class size for instructor's study load allocation, and (2) online environment guideline. Details will be described in the sections that follow.

This paper is organized as follows. Section 2 discusses some related works pertaining to the research. Section 3 presents the methodology used in this research, outlining the environmental model and content management. Results of data preparation and analysis are discussed in Section 4. Section 5 provides some in-depth discussion. Contributions and limitations are given in Section 6. Future work is projected in the final Concluding Section.

LITERATURE REVIEW

A number of online environment issues were investigated in many prior works such as student experiences in online course (Blackmon et al. 2012), online assessment, teacher training for distance learning (Burns 2011), and technology-support learning. The impact of COVID-19 on teaching and learning spreads over several areas such as higher education, Eastern Partnership (EaP) countries (Bunescu et al. 2021), student's performance and satisfaction (Gopal et al., 2021), student's perception and preference in India (Muthuprasad et al. 2021), etc. A focus on the student activity in computing subjects allowed opportunities for learning design and assessment structure.

Performance assessment is the important curriculum measurement. Oberg (Oberg 2010) showed what the students knew about content and additional skill sets within the classroom. A variety of assessment formats were used, namely, visual work, written work, oral/spoken work, and production. Online assessment was deployed (Poe et al. 2013). The student outcomes and satisfaction between traditional and web-based course (Rivera et al. 2002) in classroom versus online assessments were systematically carried out. Stowell (Stowell et al. 2010) investigated the effects of online testing, exam performance, and test anxiety by giving online testing as an alternative to taking classroom exams. Leiba (Leiba et al. 2021) investigated faculty's perspective on various benefits, challenges, and insights on distance teaching associated with both students and teachers. The significant challenges on students' potential for success were investigated by Stewart (Stewart et al. 2021) under the COVID-19 pandemic and will be elaborated later in the Research Method section. In some situations, teachers could use a mixed method teaching by (1) online and face-to-face classroom but was difficult to enact professional identity in the online classroom, and (2) a record of online teaching. This had to account for appropriate online teaching load that demanded a minimum of 14% more time than traditional instruction, wherein the ideal class size had to be considered (Tomei 2006).

One of the widely discussed issues about online environment is how much student learn during this COVID-19 pandemic lockdown. This involves many elements ranging from effective instructional planning, learner preparation, interaction via traditional/web based (Aggarwal et al. 2003, Rapanta et al. 2020), student learning readiness, organization, and self-directedness (Joosten et al. 2020), instructors, technology, personal and social supports that lack the knowledge and strategy of how to handle them (Cronholm 2021).

One may contend that implementing virtual classroom and virtual teacher might help solve the problem of training human teacher, for example, instructor inaccessibility (Blackmon et al. 2012), pre-service, in-service, and continuing education change of knowledge/skills (Burns 2011), supporting resources for how student learn, connect new knowledge, motivation, and social activities (Nilson 2010), etc.

The above selected prior works merely explain fractions of issues pertaining to online environment. We will exploit their findings as a guideline to establish components of the proposed model below.

METHODOLOGY

Unlike distance learning that encompasses both synchronous and asynchronous communications between teacher and students, online environment under COVID-19 pandemic imposes additional restrictions to handle

pedagogical and technological knowledge and resources simultaneously. The proposed models are devised to accommodate this "new normal" online learning under COVID-19, where purposive samples are from undergraduate students who attend these classes. Details of the proposed method are described below.

Environmental Model

The proposed research method uses two modes of environment, namely, off-line and online to demonstrate how the above areas can be realized and implemented. Four principal components of the instruction method are established to denote each environment mode (offline/on-line), i.e., instructor (A/A'), student (B/B'), other activity (C/C'), additional factors (D/D'), and formats of communication means (E/E'). All of these constitute the class that must be optimized to yield proper size having high instructional efficiency and effective outcomes. The proposed model is shown in Figure 1.

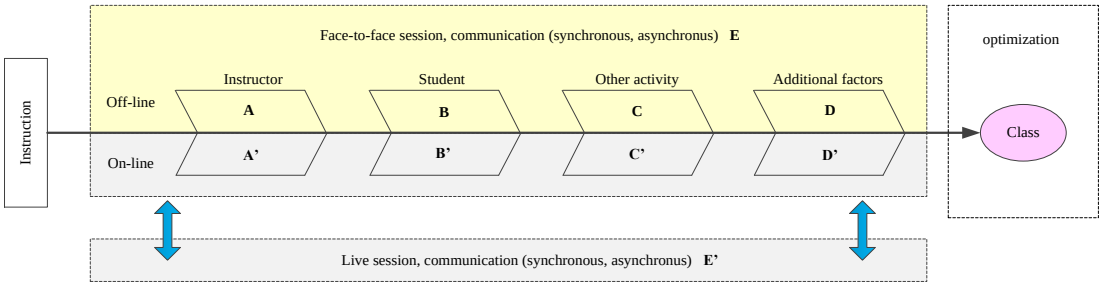


Figure 1. Proposed environment model

In Figure 1, the formats of communication means are set up slightly different for each environment due to their inherent characteristics, where X denotes off-line mode and X' denotes online mode. Off-line environment uses face-to-face communication that synchronously exchanges between instructor (A) and students (B), while other students communicate or discuss among themselves (B B) which is considered asynchronous communication. All these communication activities (C&D E) are integral parts of the classroom enclosed in the top half of dotted area. Online environment, from communication standpoint, can be conducted synchronously via interactive conversation and asynchronously via chatting between the instructor (A') and students (B') or among student themselves

(B' B'). These communication activities take place in a separate coverage

(C'&D' E'), illustrated by a detachable (changeable) setup (E') that can be changed depending on the underlying system configuration. That is to say, communication configuration can be changed to suit the specific environment requirements, ranging from remote learning (World Bank Group Education 2020), broadcasting, internet connection, live streaming, television broadcasting, etc. Table 2 compares the organization and relating activities between the two environmental modes. Activities involved in each component are explained below.

Table 2. Comparison of Off-line and Online environmental organization considerations

	Off-line	**Online**
Instructor	A) presentation in-class/face-to-face communication, discussion, gesture, additional improvision explanations.	A') preparation, presentation lecturing setup (hardware and software tool support, verbal communication protocol, supplement materials) and skills.
Student	B) attitude attentive, focus, positive participation.	B') attitude, financial support lethargic, learning climate, socio-economic factors.
Other activity	C) evaluation	C') technological training
instructor	assignments, handouts, lab preparations, quizzes, tests, examinations, grading.	learning new technologies, transforming off-line (hard) artifacts to electronic (soft) artifacts.
student	self-study of assigned materials, wet laboratory.	self-study of additional soft skills and materials, including out-of-school work, dry laboratory.
Additional factor	D) in-person attention	D') remote attention
instructor	teacher-student close relationship, personal consultation.	teacher-student communication, scheduled consultation.
student	in-class, office hours help.	limited/scheduled online Q&A.
Communication	E) built-in	E') changeable
live session	on-site/traditional lecturing.	Online lecturing.

synchronous	in-class/face-to-face discussions.	chat/text, social video network, video conference/ teleconferencing.
asynchronous	email, files, Q&A box.	email, files, messages, links, blogs, teacher and student relationship.
Optimization	appropriate class load, administrative work.	proper class size, technology infrastructure support.

The supporting guidelines in Table 2 briefly describe what is involved in off-line and online environments. The principles behind those guidelines rely primarily on technical features and specifications. For example, learning technical skills to use software tools fluently by both instructor and student attributes to all components of the proposed research method. Thus, the teacher becomes skillful using software to conduct the online environment (A/A'), effectively evaluate the course (C/C'), create exciting presentation means (D/D'), and tactfully communicate with the students (E/E') by various means. Similarly, the students can be less lethargic and pay attention to the environment (B/B') as they discover more interests in the combined wet and dry labs than read the textbooks alone (C/C') in their out-of-school work, feel warmly welcome in class or less confrontation with the instructor and their peers (D/D'), and assertively communicate with the instructor and their peers (E/E').

Additional environmental outcomes that precipitate from the proposed method are abundant, namely, participation log file, passive assessments with less personal infringement such as instantaneous evaluations, reviews, summary reports, and plagiarism check, etc. Students can also benefit from the technological support such as online lesson revival, group collaborative work, self-study environment modules, etc. However, these fruitful results come with some undesirable expenses particularly for online environment mode, e.g., economic problems burdened by hardware and software costs, social problems imposed on each student's self-esteem, confidence, expressiveness, etc.

Content Management

We decided to conduct both on-site and online environments, gathered real data from the students, and evaluated to obtain the actual results rather than to merely conduct statistical satisfaction feedbacks that relied on established hypotheses and how the questionnaire were polled and answered. Hence, the study spanned from on-site teaching in 2018 to online COVID-19 restrictive teaching in 2019-2020 that had to accommodate different environmental requirements, contents, and management. Table 3 shows the content of environment for both on-site and online settings. Since there was no physical attendance to be monitored, we prepared online data to speed up the instructional process and kept the student focused on class material.

Table 3. Content of environment

Year	environment elements	Remark
2018	participation, behavior, homework and quizzes, final exam	Behavior: tardiness, talk in class
2019-20	participation, study, homework and quizzes, final exam	Replace behavior by study

RESULTS

The experiments were conducted spanning three semesters from 2018 to 2020, covering pre-COVID-19 pandemic to the peak of COVID-19. We gathered data of each semester encompassing the following details:

teacher's skill development and related environmental support on materials, time, and administration.

online learning activities such as student-centered, collaboration, access to global resources, and multimedia presentations.

online assessment adapted to individual student characteristics, computer skills, their capacity to assimilate information, use of e-learning platform, and out-of-school connectivity.

disadvantages experienced by students due to socio-economic, feeling of isolation, digitization opportunities, delayed feedback, environmental help by teaching assistants, less free time in online than off-line learning.

Course design was set up as follows. A number of online environment elements were incorporated, namely, learning equipment such as smartphone/notebook/tablet, networking infrastructure, and the additional factors (D') that played unconscious effects on some students such as feeling isolation, impersonalization, and aggression.

Another added workload was the time required to prepare dry lab environment, participation in lab exercise, review chat messages, session video, added materials from out-of-school research, and feedbacks that were recorded during each online session. The extent as to how comprehensive every aspect to be dealt with depended on review scope, skill measurement, assessment, evaluation techniques and measurement metrics employed, and feedback for teaching improvement, etc.

A noteworthy use of equipment was the attempt to see how students coped with instant conversation and reacted to interactive discussion by means of an online meeting. It was found that the smartphone, though versatile and easy to use, had a number of disadvantages comparing with notebook and tablet as it could not function as powerful as its counterparts in writing, demonstrating, and invoking additional tasks via multiple windows, etc. These preliminaries lead to the following data preparation and analysis as follow.

Data Preparation

We set up a readiness checklist for few things to be used during the online session. Certainly, the checklist is not exhaustive as follows:

Item	Remark
Basic items	
Roster to record participation	Remind the students constant participation
"to do", "unfinished from previous session"	Improvision is unsuitable for online
Backup/pertinent materials to current lessons stored in a portable drive and readily connected	Avoid frequent Internet searches that disrupt the instructional flow
Pencils, markers, notepad, etc.	Jot down things to be remembered or done
Additional items	
announcement	Email, social network
session overview	Email, webinar
tutorial	e-book/e-document
demonstration	Video clip, animation
practice	Shared online workbook assignment
evaluation form	Instructor and students

Figure 2. Readiness checklist

The above itemized checklist seems obviously banal in comparison to computerized tools. However, they are lifesaver for online environment that prove to work any time and everywhere, particularly when the equipment or network connection sporadically fail. Item #1 not only helps call to their attention, but also find out why some students do not actively participate when they are called upon. One frequent evident: they connect with a smartphone which prevents them from participating in activities other than simple texting, that is, they cannot demonstrate or derive mathematical formula with their smartphone. The reasons are that they cannot afford expensive PC/notebook/notepad, or they are at work, on-the-run, but do not want to miss the lecture. Item #2 alleviates the instructor from having to recall dozen of previously left-out or will do activities. Students are watching live and soon becoming tired of the instructor's frequent improvision, hence degrading their attention. Item #3 lessens the frequent switching back and forth from Internet searching for the desired materials, especially when the network traffic is high. It shows the readiness on the instructor's part that can promptly access and retrieve pertinent materials. Item #4 represents the good old gadgets that could be handy, work 100% of the time (especially when software tools malfunction) with the least effort. Item #5 must be announced in advance. The remaining items #6-#10 are parts of regular environment's manual/guide.

Class size is another important factor for online environment to handle efficiently. Unlike some local universities that offer online courses with unlimited attendees for each class using one-way communication, online interactive environment with COVID-19 lockdown cannot be conducted in that manner. To determine an appropriate class size, we resort to quantitatively formulate the proposed model based on the following average student's registration and attendance:

There are approximately 25-30 students registered per section (X1).

Each student is taking at most 5 subjects per semester (X2).

There are no more than 5 homework assignments and 2 quizzes per subject (X3).

The frequency of each student's (encouraging) participation in class is at most two per session to leave a fair share for the rest of the class (X4).

The online class size (Y) is determined by the above four factors to attain a suitable size to be taught by an average instructor efficiently. We will demonstrate an in-depth analysis in the next section.

Analysis

Problem formulation was established by means of a well-established Linear Programming (Vanderbei, 2020; Panik, 2018; Thie et al, 2011) technique as shown below. Let the objective function of workload for each subject per semester be

$$\max \quad X1 + 1/5X2 + 7X3 + 14X4$$

subject to

$$X1 \leq 30 \quad (1)$$

$$X2 \leq 5 \quad (2)$$

$$X3 \leq 7 \quad (3)$$

$$X4 \leq 2 \quad (4)$$

where we account for individual as X1 class; we tally only single subject per student in each online class, hence 1/5X2; homework and quizzes amount to 7 assignments or 7X3; and midterm takes away one mid-semester week, reducing the actual instruction to 15-1=14 weeks or 14X4. Thus, there must exist nonnegative numbers s1, s2, s3, and s4 which can be added to the left side of each inequality to produce a system of linear equations as follows:

$$X1 + s1 = 30 \quad (1)'$$

$$X2 + s2 = 5 \quad (2)'$$

$$X3 + s3 = 7 \quad (3)'$$

$$X4 + s4 = 2 \quad (4)'$$

Solving the above systems of equations (1)' – (4)' in accordance with the objective function, we obtain the workload 108 person-week or equivalently $108/14 = 7.714 \approx 8$ students per week. Notice that this solution focuses on (i) proper attention to each student, (ii) reasonable workload for each instructor, particularly scientific-oriented assignments and quizzes that involve comprehensive algorithmic computations and derivations, and (iii) upper-level class environment. However, the solution does not take economic, social, and educational factors into consideration. For example, the economic factors such as set up and overhead costs for the online session are not cost-effective for only a handful of students per session; the social factors such as some students may not prefer close attention or live correspondence with the instructor; the educational factors such as too many online sessions for such a small session size will create teaching incoherence and uniformity among instructors for the same subject. At any rate, we will use the quantitative solution to arrange the format of proposed online environment.

The above solution under the given scenarios provides a starting point for actual online environment class schedule. In every semester, the department offers approximately 10 electives and 5 mandatory subjects for students to register. Given each student has to take 5 subjects per semester, the maximum combinations of choosing 5 classes out of 15 subjects is equal to $\binom{15}{5}$ or 3003, which is the maximal class schedules. In practice, the 8-student solution provides a tentative average registrant for most electives, while compulsory subjects receive full class registrants. Thus, class schedule arrangement reduces considerably. In this study, there were slightly over 8 students for some elective classes, which were still manageable workloads by the instructors.

In summary, the proposed research method furnishes a flexible environment model representing 4 descriptive elements, namely, instructor, student, other activity, and additional factors. These elements provide the bases

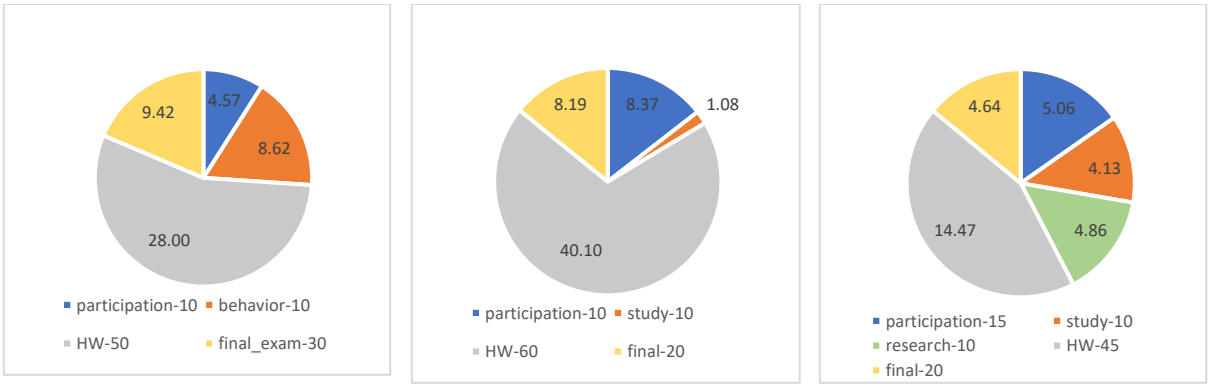
for a quantitative analysis of appropriate class size to accommodate economic, social, technical, and body of knowledge for online environment management criteria. The COVID-19 pandemic happened to enforce an ad hoc implementation of the scheme that yielded some fruitful results to be discussed in the next section.

DISCUSSION

We conducted a postmortem analysis to compare on-site students' performance before COVID-19 pandemic with online environment during COVID-19 pandemic. Of particular unique for these pedagogical methods was out-of-school communication with online environment. Our plan was to provide students with connections after the online session for their material research, connection to additional academic resources, homework and assignments, and collaboration.

A few interesting outcomes were precipitated which were worth discussing. Out-of-school work turned out to yielded better quality of write-up, extended readings, gave more comprehensive work output, and furnished new ideas and cutting-edge techniques. These were conducive toward student learning to a large extent.

Another important outcome was proper class size that provided maneuverability of environment planning and analysis to handle all the students properly and individually. Figure 3 shows three class evaluation outcomes from the above established content management. Figure 3(a) shows the average on-site students' performance statistics based on conventional point-spread, namely, 10% participation, 10% behavior, 50% homework and quizzes, and 30% final exam. The average score of each category was 4.57/10, 8.62/10, 28.00/50, and 9.42/30 from participation, behavior, homework and quizzes, and final exam, respectively.



(a) 2018 score [63.04%,5A,0F] (b) 2019 score [63.54%,3A,2F] (c) 2020 score [53.28%,0A,1F]

Figure 3. Grading allocation and distribution of class evaluation.

Figures 3(b) and 3(c) demonstrate the same interpretation. Discussion was distributed evenly among all students at a faster pace. We increased homework and quiz loads slightly from 50% to 60% to maintain study activities at high level. The class average remained relatively the same at 63.04% (2018) and 63.54% (2019). There were 5A as opposed to 3A and 0F as opposed to 2F grades in 2018 and 2019, respectively. This did not reflect any significant student's performance improvement during 2019 COVID-19 pandemic since some of them dropped the class due to infection. The degradation prompted a few adjustments in the class assignments based on Table 3, namely, homework and quizzes were reduced to 45%, giving rise to participation at 15%, and research reading on topic to be discussed at 10%. Nevertheless, the results were still not improved from those of 2019 since some of the students were suffering from recurrent infection. The average fell to 53.28%, but fewer students dropped the class. There were 0A as opposed to 3A and 1F as opposed to 2F grades in 2020 and 2019, respectively.

It turned out that the following factors were attributive of performance degradation for a few students:

Some students lacked self-discipline/self-directedness to maintain their independent study, hard-working attitude, and organization to work.

Some students had economic/financial problems that they could not afford proper equipment, supporting software, and infrastructure charges to participate in a fully equipped fashion for online environment. Yet few had to skip class occasionally for extra jobs to make ends meet.

Some students did not follow the instruction continuously to envision how all things made up the whole picture. In other words, online environment could not replace face-to-face instruction as far as comprehension and clarity of interaction and continuity of question and answer, and class demonstration on actual problem-solving drills, etc.

The lessons learned from two-year COVID-19 pandemic online environment with a period of lockdown revealed a few aspects for improvement on how to build the contents and supplement materials. The materials had to be short and interesting to get the student's attention to participate so that, upon in-class drills, they understood the content and were able to implement it. In addition, an open off-line assistant channel such as a 24x7 chat channel was conducive toward student satisfaction who felt comfortable chatting off-line rather than asking questions during Q&A session. On the contrary, some students felt being isolated from peer and kept silence with no feedback, while others acted aggressively since they turned off the camera believing that no one could recognize them. One easy fix was to drop the voluntary participation policy (as in on-site session) and follow the roster, ensuring that no one was left behind. All these findings will be invaluable to future planning and implementation of online and on-site environments. Administration must not over-emphasize on managerial issues and overlook the human needs for instructors and students.

The flip side of this online environment was learning loss by some students who were not yet ready for this way-of-learning because it might not fit well with their attitude and personal liking. We found an online environment truth that the diligent learned, but the lethargic did not. Yet social concern was personal contact among students. They did not know one another when they met during the first few on-site reunion. Although they might get to know one another quickly, the relationship was not built in a few days in so far as the good old small talk experiences that they never had during the two years of online learning.

Contributions and Limitations

The proposed model supports theoretical pedagogic study and practical instructional process in the following aspects:

The model is switchable between online and off-line modes, offering continual implementation for subsequent instruction "after" COVID-19 pandemic,

The communication module can be flexibly setup in accordance with environmental establishment, that is, a) using campus WiFi to broadcast the instruction if the instructor is on campus and the students are attending at home, or b) using instructor's internet equipment to broadcast the instruction from home while the students are also attending at home. The se

change is done independently from the instructional module to fit the environment where the instruction will be broadcast. Thus, the practice is still exercised long after the pandemic is over, and

Instructors and students alike can compare notes, materials, ideas, etc., widely through the communication exchange, leading to better collaboration academically.

The quantitative guideline for proper class size determination also yields serval benefits that are worth mentioning as follows:

Students understand the material better than an over-crowded class,

Instructors have less workload and hence are better prepared for class,

Closer attention can be paid to individual student,

Out-of-school connectivity helps improve the student learning effort and confidence,

Higher instruction efficiency is obtained from properly go-around with students' participation, interactive discussions between instructor and students, and less stress on peer pressures on the student's part, and

Curriculum planning and budgeting can be efficiently organized by the academic administration, especially for electives, in terms of student headcount, class schedule, classroom occupancy, and related services and supports such as overhead projector, audio, video, instructional software setup,network connectivity, etc.

The proposed quantitative approach currently is based only on four bases, namely, the number of students registered per section, subjects taken by each student, number of homework assignments/quizzes, and frequency of in-class participation. Our experience on online environment under COVID-19 pandemic situation was different from regular distant learning programs in that a complete lock-down was imposed at the peak of the pandemic. One important limitation was the lack of wet lab availability. The fact that dry lab only exhibited the 'how-to' procedure for S&T students to learn, while wet lab permitted the 'real touch' that fostered the skills needed for experimental knowledge and occupational experiences. At any rate, every trial-and-error combination of contents, techniques, supplementary materials, etc., of the lessons is worth exercising. The results will be sorted out and compiled to interpret what factors contribute to better outcome for future work.

CONCLUSION

Future work could expand the horizon of bases to include more elements that directly or indirectly are relating to online environment characteristics and operations such as budgeting, student's income, accreditable software quality of service, different student's performance evaluation methods other than grading, and so on. One noting future enhancement will be the provision of wet lab, where the administration must make budgetary arrangements to support it.

There should be student consultations and helps as far as out-of-school work is concerned to get every student up to speed. Thus, the quantitative solution obtained would serve as a more comprehensive measuring instrument than questionnaire inferences. Other evaluation techniques and measurement metrics must also be considered since the 'new normal' brings about new way of teaching, studying, tools, skills, human factors, management, etc. These factors must be dealt with to efficiently handle this new form of online environment method.

In addition, it is essential to investigate how to blend the advantages of both environmental modes to benefit the best of both worlds such as class size planning that suits environmental efficiency and budget economy, chatting that serves personal advisory to students, and identifying ways to get the student's attention, etc. One avenue that can be exploited is the video recording of the online sessions for subsequent viewing, reviving the lesson, missing class make ups, etc.

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