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IN THIS ISSUE

Vision and Mission of the IJODeL

Vision

To be a leading international academic journal that publishes and disseminates new knowledge and information, and innovative best practices in open and distance e-learning.

Mission

The IJODeL shall publish and disseminate new knowledge and information based on original research, book reviews, critical analyses of ODeL projects and undertakings from various researchers and experts in the Philippines, the ASEAN Region, and the world, and concept articles with the intention of presenting new ideas and innovative approaches to interpreting and implementing best practices in open and distance e-learning as alternative delivery mechanisms for quality education.

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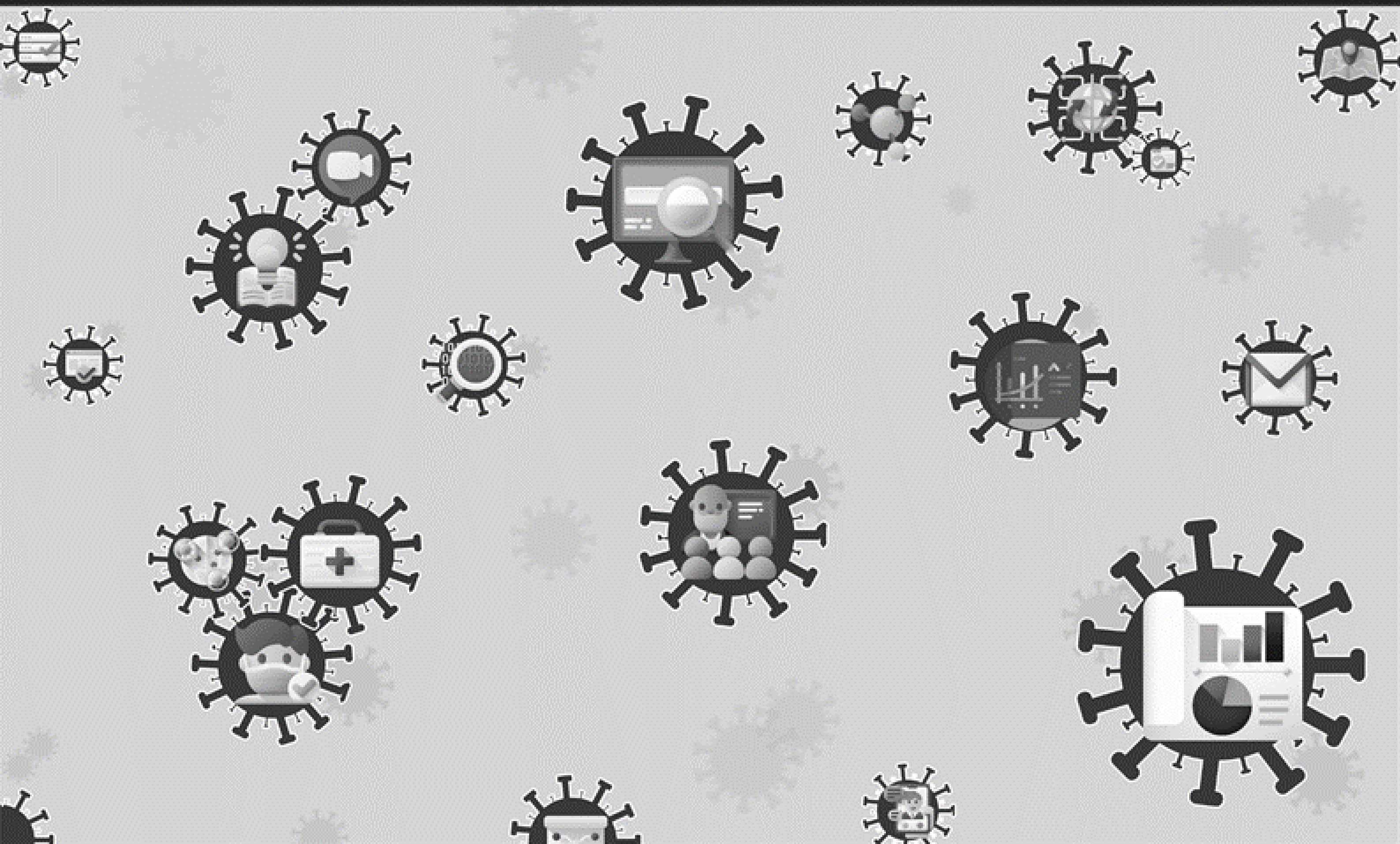

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A Thematic Analysis of UPOU's Virtual Roundtable Discussions (VRTDs) on the University of the Future

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Abstract

The impact of the Industrial Revolution 4.0 (IR 4.0) on education has been widely discussed in recent literature. Referred to as Education 4.0, teaching and learning in the future is seen to be largely influenced by advances in technology brought about by IR 4.0. This has prompted the education sector to evaluate the educational system and envision its future.

Like most other educational institutions, Philippine higher education institutions (HEIs) are challenged to rethink and retool themselves for the "new normal" and future scenarios. University of the Philippines Open University (UPOU) embarked on a participative, reflective, and forward-thinking discussion series through virtual roundtable discussions (VRTD) on the University of the Future (UoF).

This study presented the collective thinking of UPOU's constituencies as captured in the VRTDs conducted from November 2020 to January 2021. A thematic analysis was conducted to surface themes arising from the transcript of five (5) VRTDs on the UoF conducted by UPOU with its faculty, students, staff, and alumni as participants. To contextualize the emerging themes, these were superimposed on the Open and Distance e-Learning (ODeL) subsystems.

The two arising themes were radical transformation and peripheral adjustments. Both refer to the different ways in which the UPOU can transform into a UoF, emanating from the VRTD discussions. An overarching theme of seamlessness was further abstracted. In becoming a UoF, a seamless UPOU is envisioned to be permeable and porous enough to be equal in prestige and purpose with its surroundings.

Keywords: *university of the future, ODeL, ODeL subsystems, UPOU, thematic analysis*

Introduction

Technological advances have historically found their way to influence how work is done, and consequently, how learning takes place (Demartini & Benussi, 2017). This is evidenced by how society has been influenced by key innovations and discoveries from past centuries, such as the steam engine, electricity, and computing (Elayyan, 2021). Today, the world finds itself in the middle of yet another revolution— Industrial Revolution 4.0 (IR 4.0). This time, the change is amongst emerging technologies by the names of big data analytics, artificial intelligence (AI), cloud computing, and faster mobile connectivity. IR 4.0 is largely composed of "smart" technologies that integrate and hyper-connect systems and data for better-coordinated functions in the physical, digital, and biological spheres (Schwab, 2016).

The impact of IR 4.0 on education has been widely discussed in recent literature (Koul & Nayar, 2021; Tanriogen, 2018). The World Economic Forum (2018) projects that as machines take over routine work, educational institutions will have to ready a nimble workforce that embraces learning as a continuous process. It is through this background that Education 4.0 (Educ 4.0) has emerged. This new model aims to respond to the evolving needs of IR 4.0, especially concerning higher education. Here, learners are at the center of a transforming educational universe. Thus, personalization of the learning experience and lifelong learning become core features in Educ 4.0 as a way to address uncertainties continually presented by a still emerging IR 4.0 (James, 2019).

It is projected that universities will be further enabled by Web 4.0— a new era where a benefitting relationship exists between humans and machines (Salmon, 2019). Powered by IR 4.0 tools and Web 4.0, universities are expected to offer personalized learning experiences (Ovinova & Shraiber, 2019), emphasizing systems and design thinking in the curriculum delivered via authentic, effective, and efficient modalities (Salmon, 2019).

To ensure its graduates will thrive in a still unknown and uncertain future, universities will have to create an environment where learners are given every chance to own and master the learning process. Ra and colleagues (2019) refer to this as "learnability" (p. 26). They also suggest that a way to facilitate this is through a "learning society" (p. 34), where quality learning opportunities are available anywhere and anytime to anyone (Ra et al., 2019). To date, there have been some attempts to put forward the concepts of learning society, as seen in the work of Bonfield et al. (2020), who presented an overview of how various universities have risen to this challenge by revolutionizing program offerings, design, delivery, and support with the learner at the core of the innovations. However, even with the innovations within reach, the transition to Educ 4.0 can be delayed by factors external to the university (Qureshi et al., 2021). Further, if universities are to ready their learners for IR 4.0 and embrace Educ 4.0, an overhaul of the existing systems anchored on tradition is necessary (Pogorelskaya & Várallyai, 2020).

Objectives

This research intended to capture the collective thinking of University of the Philippines Open University (UPOU) constituencies as revealed in the virtual roundtable discussion (VRTD) series on the University of the Future (UoF) conducted from November 2020 to January 2021. Specifically, the study identified emerging themes from the VRTDs and looked into the challenges to reconfiguring open and distance e-learning (ODeL).

Literature Review

Future Universities

Literature presents global discussions on the future of universities. These discussions are grounded by changes in the educational landscape as affected by various factors. Understanding the conceptions of the future of universities requires insights into the present context, that is, the 21st century, coupled with "modest" predictions (*first logic of prediction*; Bridges (2000). Nevertheless, in addition to the first logic of prediction, it would also be important to consider looking into preceding notions to contextualize the present scenarios. Forecast of the future universities may not be limited to the structure but may have branched out to other key aspects of the educational system such as degree/course, instruction, student, among others.

In the mid-to-late twentieth century, technology was seen as a major contributor of the educational landscape adjustments in the future (Johnston, 1998; Peston, 1979; Suchodolski, 1974), among other drivers of change (e.g., environmental, social changes). It is expected that technology will play a major role in the educational landscape of the 21st century wherein, Bridges (2000) reported the "profoundly disruptive potential of web-based learning" (p.1) in the future of higher education curriculum.

Such emphasis on information and communication technology (ICT) integration has successfully positioned technology-driven educational systems, such as open and distance learning (ODL), e-learning, and virtual universities, at the forefront of future universities. Literature asserted the role of these technology-driven educational institutions in mapping out the UoF (Conway, 2020; Daniel & Kanwar, 2008; Halloran & Friday, 2018; Long, 2013; Sertu, 2018; Wolf, 2001). There is much contention on whether such education systems will replace the brick-and-mortar setup. In some cases, adjustments are being adopted as online learning is seen as an alternative solution to campus-based learning in terms of widening reach and infrastructural limitations (Long, 2013). Sertu (2018), on the other hand, proposed that the UoF will be a "hybrid of the old university model and emerging models" (p. 2; see Minerva Project).

Nevertheless, several conceptions on the UoF in technology-driven educational environment highlights electronic means of teaching and learning, learning environment, and assessment (Wolf, 2001); online learning (Long, 2013); multi-institutional and multi-credit qualifications (Peters, 2016); unbundled traditional degree programs, rise of freelancers and network of universities (Halloran & Friday, 2018); massive open online courses (MOOCs) (Conway, 2020; Guri-Rosenblit, 2019; Sertu, 2018); focus on marginalized learners, wide development and use of open educational resources (OERs), academic and student support systems, and partnerships and collaborations with other HEIs, corporate, and work worlds (Guri-Rosenblit, 2019); and personalization of learning experiences and availability of learning options (Conway, 2020). Notably, even the concept of lifelong learning will be largely influenced by ICT (Wolf, 2001).

Meanwhile, there are also configurations in terms of future pedagogy and instruction. The future of delivery in online education looks into the potential of stand-alone instruction and online multimedia environments. The former advocates student-to-content (non-human interaction) in instruction, while the latter encourages the use of "well-designed Internet-based instructional models" (Gaytan, 2007). Witthaus et al. (2016) focused on the future pedagogy in an online and blended higher education environment. Through the FUTURA project, Future of University Teaching: Update and a Roadmap for Advancement, future teaching should consider technological aspects, collaborative partnerships and services disaggregation, student engagement, flexibility and responsiveness to learners' needs, curriculum's real-world relevance, and learning process contextualization (Witthaus et al., 2016).

In this digital age, technology-driven institutions need to leverage their technological affordances as the future of education is seen to be largely influenced by technological advancements. The reviewed articles highlight that universities in the future will have to give more emphasis on the digitization of curriculum and pedagogy, personalization, and contextualization tailoring the learners' varied and individual preferences, continued pursuit of lifelong learning through ICT, exploration of unbundled degree programs, and the network structure of universities. Even with these numerous conceptions, literature often focuses on separate areas of an educational system (i.e., structure or pedagogy alone). A holistic approach to the topic may be quite challenging due to its complexity, but this will aid readers in visualizing the UoF as a whole.

Systems Thinking in Education

In a review of Laszlo and Krippner (1998) on the origins, foundations, and development of systems theories, seminal work on the General Systems Theory (GST) takes its roots from Ludwig von Bertalanffy during the first half of the 20th century wherein he laid down the concepts of the GST as provided below (p.5).

> (1) There is a general tendency toward integration in the various sciences, natural and social. (2) Such integration seems to be centered in a general theory of systems. (3) Such theory may be an important means for aiming at exact theory in the nonphysical fields of science. (4) Developing unifying principles running "vertically" through the universe of the individual sciences, this theory brings us nearer the goal of the unity of science. (5) This can lead to a much-needed integration in scientific education.

The systems theory, which started in the field of organismic biology, later on, extended its application to humanities. Multidisciplinary application of systems approach is possible because it is used as a general form of inquiry that allows investigation of complex interactions, whether intrapersonal, interpersonal, intergroup, and human/nature, in a holistic sense rather than individually (Laszlo & Krippner, 1998).

Proving the capabilities of this perspective for interdisciplinary application, Banathy (1996, as cited in Daniel, 2006) worked on systems design in the educational context and stated that the strong application of systems approach in education positions us "to explore and characterize the system of our interest, its environment, and its components and parts in a different way" (p. 3). Pahl and Richter (2009, as cited in Pogorelskaya & Várallyai, 2020) mentioned further that education as a system could be viewed as a whole while noting its environment-system interaction and its various sub-systems components.

The definition of "systems thinking" has been interpreted in a variety of ways across disciplines. In a comprehensive study by Arnold and Wade (2015), the following definition of systems thinking was proposed and was adopted in this study: "Systems thinking is a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviors, and devising modifications to them in order to produce desired effects" (p.675). Systems in this study are characterized as "groups or combinations of interrelated, interdependent, or interacting elements forming collective entities" (p.675). Arnold and Wade also proposed a "systems test" that comprises completing these three conditions: (1) function, purpose, or goal, (2) elements, and (3) interconnections to be recognized as a system.

In interpreting and visualizing systems, models, which are simplified versions of a system, are used to understand and forecast its future behavior. With the use of models, the systems can be looked into to be able to clearly understand, describe, and analyze them. In delineating the scope of a system, one must first define its boundary, which means that there must be a selection of the entities, processes, and interactions to be included inside and outside the system. The entity outside the system is then called the "environment," which is also known as the "supersystem" within which the focal system operates (Garcia, 2018).

In the case of human and conceptual systems such as the educational system as a unit of analysis, the boundary line between the system and its environment is not as well-defined as other physical systems (Laszlo & Krippner, 1998). Moreover, educational systems were also considered as open systems, which were described by Geoffrey (1983, as cited in Daniel, 2006) as "nests of relations that are sustained through time by their relations and by the process of regulation; they depend on and contribute to their environment; and they operated as wholes, but are also parts of larger systems, and their constituents may also be constituents of other systems" (p. 4).

All this implies that in exploring the design of educational systems, the focal system must be clearly defined and its nature as a system must be considered. Three (3) system models in viewing educational systems were developed by Banathy (1996, as cited in Daniel, 2006) that include (1) systems-environment models, (2) function-structure models, and (3) process-behavioral models.

Open and Distance e-Learning system

As an educational system, ODeL comprises different subsystems. In the context of UPOU, system components are similar to that of the DE subsystems mentioned in Moore and Kearsley's (2012) DE systems.

One of the comprehensive discussions of the ODeL system was in 2015 during the National Conference on Open and Distance eLearning. The conference covered four subsystems namely, course design, teaching and learning, student support, and organization and management (UPOU, 2017). The recent version of the system, which the study adopted, was explained by Garcia (UPOU, 2020) to include course delivery as the fifth subsystem.

In this section, ODeL was viewed as a system that is composed of five interrelated subsystems, with the management subsystem serving as the integrator. Compared to the DE system, where the ODeL system was derived, the difference lies in the accompanying practices of each subsystem. The following includes the distinguishing characteristics of each subsystem, as stated by Garcia (UPOU, 2020).

Course design subsystem. This covers the learner profile and the design and development of the course and course material (e.g., self-contained course packages) using an unbundled approach. Specifically, it involves aligning the course and the learning outcome based on the profile of learners, connecting the course pathways in terms of learning outcomes, identifying appropriate assessment tools, and breaking down topics for a comprehensive approach.

Course delivery subsystem. Courses can be delivered via print, online or web-based, and others (e.g., audio, video, computer-based, combination). The organization's mission and vision, target learners, cost, and availability of technology are the variables that affect the kind of delivery systems the institution will adopt. The type of delivery system determines other factors that must be considered. For example, print-based delivery systems consider printing materials, courier or postal services, warehousing and inventory management of the print materials, whereas online/web-based delivery systems ensure connectivity for all its academic and support staff and accessibility of learning materials.

Instruction subsystem. This subsystem centers on the role of teachers in the learning process (e.g., student advising, giving feedback), among other functions of the instructor (e.g., administrative). For distance education (DE) institutions, creating an effective student-teacher and student-student interaction, and evaluating the effectiveness of the course design are crucial.

Student support subsystem. For this subsystem, types of services, delivery practices, and support staff competencies are highlighted. Services may include tutorials, counsels, library services, helpdesk, technical support, study or learning centers development, and admission concerns accompanied by a support staff system equipped to facilitate these services.

Management subsystem. Unifying these subsystems is the management subsystem. This subsystem connects all components by undergoing: 1) needs assessment and prioritizing, 2) resource allocation and administration, 3) personnel recruitment and training, 4) monitoring and evaluation, 5) policymaking, and 6) implementation, monitoring, and evaluation of a quality assurance (QA) system in ODeL. Ensuring the support of the stakeholders is crucial in all aspects of the management subsystem. This participative nature stresses the role of management in uniting all subsystems.

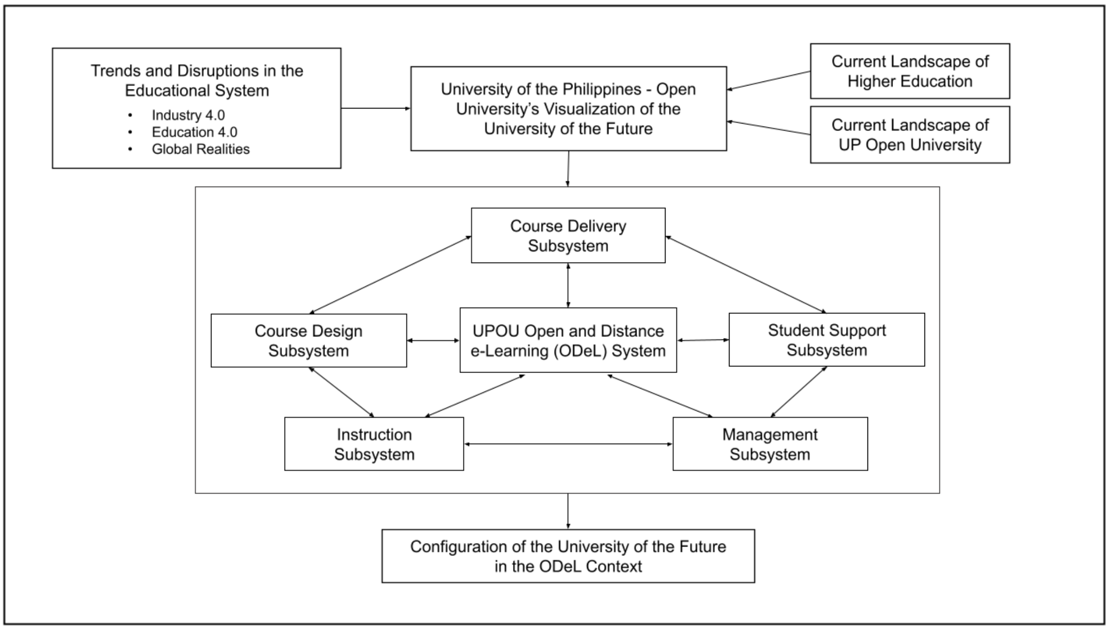
Systems Design of ODeL

Banathy (1992) pointed out that "systems design is the only viable approach that enables our communities to work with constantly evolving new realities to create and recreate their systems of education in a changing world" (p. 41). Building on the conceptions presented in the VRTDs and what the researchers infer, systems design illustrates a framework that will guide the whole research study.

To synthesize the previous sections, components from the reviewed literature served as elements in the study framework to inform the overall configuration of UPOU as the UoF using an ODeL system. Literature suggests considering drivers of change in the educational landscape as well as the current context in the educational system. To capture a holistic view, the ODeL subsystem was used to cover all areas in the education system of UPOU. Understanding the interconnections between these elements is crucial and regarded as the first step in systems thinking (Arnold & Wade, 2015). Hence, the results should point out the interconnections within the ODeL subsystem. Figure 1 illustrates the interaction of the ODeL subsystems as it relates to the overall configuration of UPOU as the UoF.

Figure 1

Study framework in designing the UoF configuration



Trends and disruptions in the educational system were primarily driven by technological innovations that caused the development of Industry 4.1 and Education 4.0. Contributing to this are the global realities such as climate change, globalization, and socio-political factors. Compounded by the current landscape of higher education to which the underlying systems of the university rests upon, these concepts altogether contribute to the discourse of what a future university may look like.

As seen in Figure 1, at the center of this study is the ODeL systems conceptual model adapted from Garcia (UPOU, 2020) that illustrates further the interrelationships between the subsystems comprising the ODeL system of UPOU. These five interrelated subsystems cover the teaching, learning, and administrative components of an educational institution. At the course levels are design and delivery components of the content and how the content is administered. Teachers and learners, as the main actors in the teaching and learning process, constitute two subsystems. The former is emphasized through the roles and functions it assumes as well as the support needed, while the latter highlights the kinds and ways to assist their learning with complementary support to the service provider staff. Lastly, at the administrative level is how the other four subsystems are strategically planned, implemented, monitored, and benchmarked to attain the best-expected outcome of these subsystems. The interaction and/or overlap between the components of each of these subsystems will inform the overall configuration of the ODeL system of UPOU. Overlapping categories were considered based on their direct impact on the subsystem.

Research Methodology

Research Design

The research focused on the participants' viewpoint on ODeL from the five VRTD series on the UoF. Thematic Analysis (TA) was the chosen methodology to identify emerging themes on the future of ODeL. TA is a widely known research method for identifying, analyzing, and reporting patterns within data which is known as "themes" (Braun & Clarke, 2006). Given its flexible nature, it can also serve as a tool to surface an intricate amount of data.

To generate themes, recording units were gathered from the UoF VRTD transcripts. Recording units or coding units, as defined by Krippendorf (2004), are the units that are identified for individual description, transcription, recording, or coding. Interpretive and inductive approaches were used to reveal and analyze meanings from the transcripts. More so, the study was guided through a framework to provide utilization to the meanings.

Participants and Background of Researchers

UPOU VRTDs consisted of the faculty, students, staff, and alumni as participants. The researchers consisted of project staff, faculty, and attendees of the fora. At least one of the researchers was present during the forum.

Data Analysis

In this study, the researchers conducted descriptive and *in vivo* types of coding to identify the emerging categories from the VRTD transcripts (see Appendix A). The VRTDs were transcribed by the researchers. As for the generation of each code, the researchers conducted the solo coding of each VRTD Transcript. Consultation among the team after solo coding is one way of verifying findings (Saldaña, 2013). All codes from the five transcripts were grouped under the five ODeL subsystems.

To ensure the utility of results, systems design and ODeL subsystems were used for further interpretation. The consolidated codes under each subsystem were reviewed and categorized individually and as a team into sub-themes. Maps were then created to depict relationships between ODeL subsystems and categories. Overarching themes were identified through making sense of the sub-themes and categories.

Data Privacy and Confidentiality

The VRTD participants were informed that the sessions were being recorded as part of UPOU's initiative on UoF, especially in the conceptualization of the University of the Future in UPOU. Hence, the sessions were recorded with their consent.

For this study, the audio-video recording that was obtained from the organizing team was encoded into textual transcripts. The texts analyzed were anonymized and were not directly attributed to the speaker/attendees. No sensitive information was drawn from the participants of the VRTD series.

All data are stored in Google Drive hosted by the university email. The sharing settings of Google documents and sheets were restricted and only accessible to the researchers. All data obtained from participation in the study were treated with the utmost confidentiality and will not be released by the researchers to any third party.

Results and Discussion

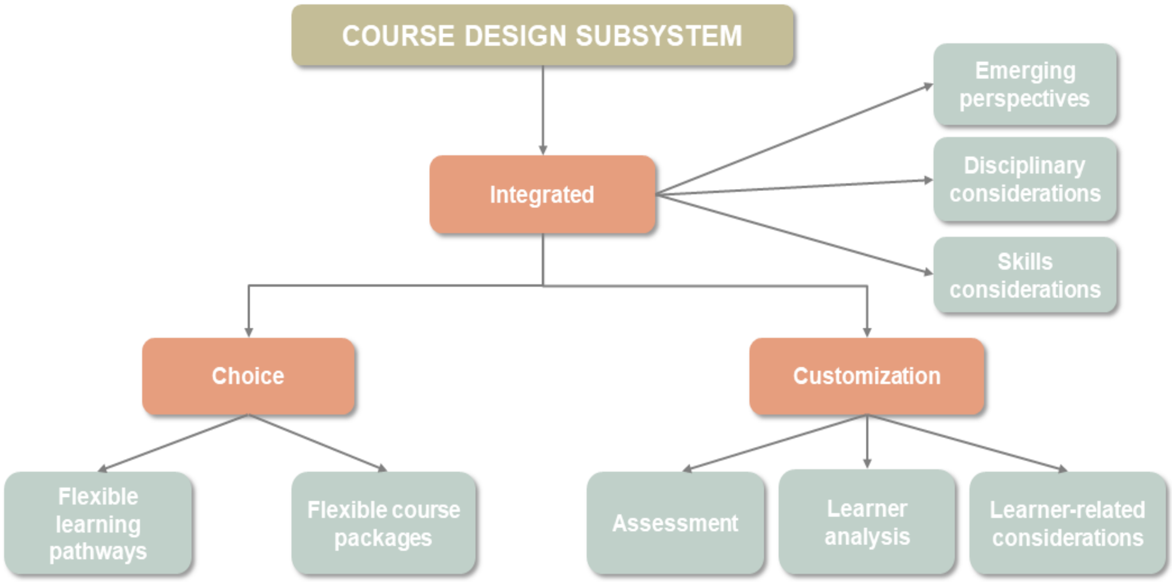
This section presents the latent content gathered from the VRTD transcripts. The researchers analyzed the surfaced meanings using the ODeL subsystems framework. First, categories and sub-themes for each subsystem that are embedded in the design were elaborated. Lastly, the configuration of UPOU as a UoF was discussed through the emerging and overarching themes.

Course design subsystem

The course design subsystem, as shown in Figure 2, is composed of eight (8) categories subsumed under three (3) sub-themes arising from the codes for this subsystem. In a nutshell, the researchers found that this subsystem should be integrated enough to offer choice and customization in a UoF setting.

Figure 2

Thematic map of the course design subsystem



The VRTD participants pointed to a common ground for creating enough options to customize learning programs. To achieve this, participants also recognized that this subsystem must be integrated in such a way that relevant stakeholders are engaged to enable such features. The stakeholders being referred to here include the industry, the university, and the academic fields.

In terms of program offering, the participants envisioned more flexibility in how current degree programs are offered and operated in a UoF. This was evident in the participants' call for stackable credits, recognition of prior learning, and micro-credentials. Such transformations also have implications for course materials and course packages. Further, the element of choice and customization becomes more apparent when programs recognize the unique context of each learner.

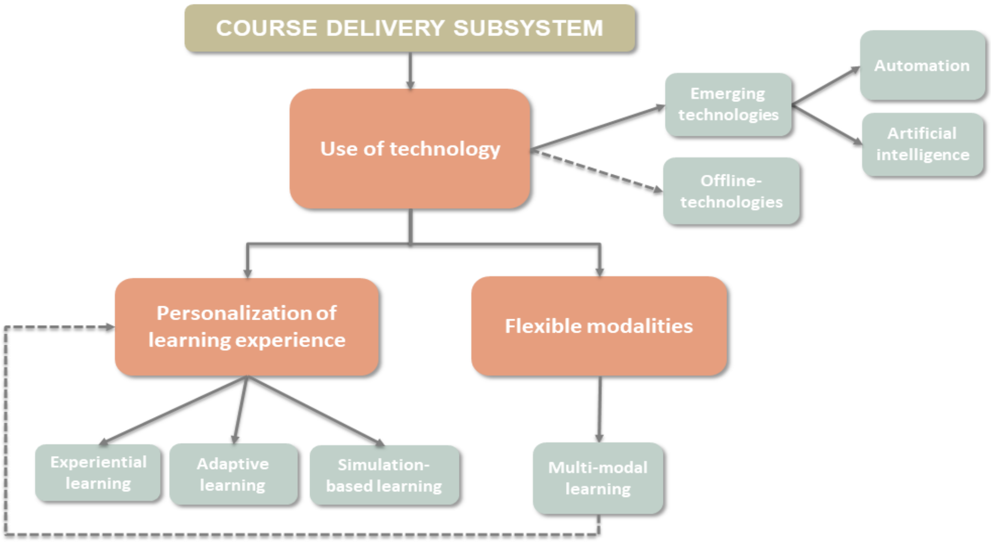
On the other hand, participants also stressed the importance of a pluridisciplinary and transdisciplinary approach to designing the curriculum. This implies more cooperation among disciplines as opposed to working in silos. Moreover, the literature suggests that this is necessary if universities aim to prepare an IR 4.0-ready workforce. In such workforce, communication, critical thinking, innovation, sustainability, and social skills are as important as technical expertise in the future (Bridges, 2000).

Course delivery subsystem

Figure 3 shows the conceptions on this subsystem which emphasize modern technologies influencing the approaches/methods for flexibility and personalization of the learning experience. This includes the use of emerging technologies such as AI and automation, which are associated with IR 4.0. An opposing view was also mentioned to include the use of offline technologies.

Figure 3

Thematic map of the course delivery subsystem



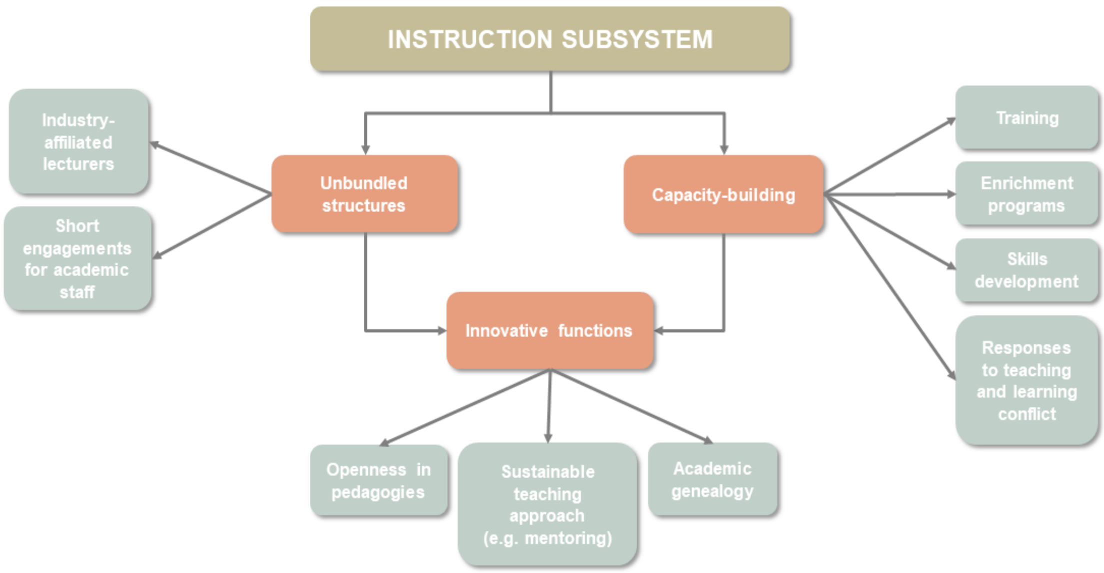
The use of technology in course delivery branches out to integrate with personalization of learning experience (e.g., experiential learning, simulation-based learning) and flexible modalities.

Instruction subsystem

As presented in Figure 4, the VRTD participants highlight three (3) main points in conceptualizing instruction in the university of the future.

Figure 4

Thematic map of the instruction subsystem



First, capacity-building should be strengthened. It is imperative that there must be continued support mechanisms such as training, enrichment programs, skills development, and responses to teaching and learning to equip the academic staff to respond to changes in the landscape of the UoF. Second, the participants proposed an unbundled structure that involves industry-affiliated lecturers and short engagement of academic staff. This proposed structure would have an implication on tenure. The former relates to lifelong opportunities formed involving practitioners and non-practitioners. On the other hand, the latter is described as an observation/trend that is currently happening in the university. Combining these two would result in innovative functions in the instruction, which include: (1) openness in the pedagogy, (2) sustainable teaching approach such as mentoring, and (3) academic genealogy usage that would serve as the basis of future discipline.

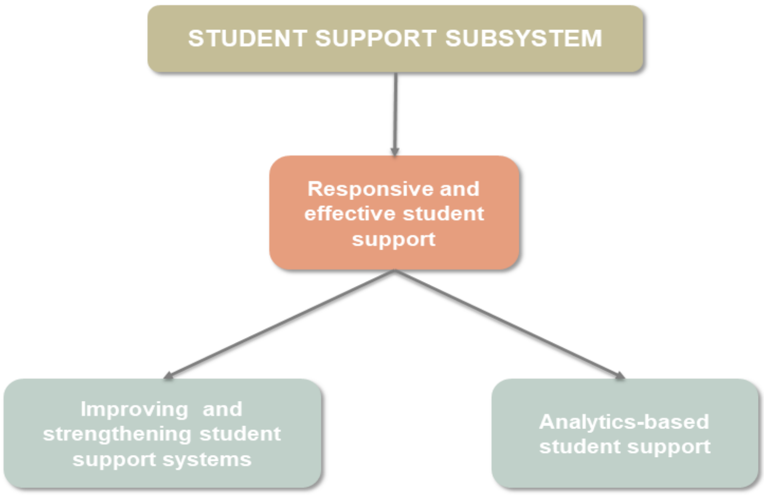
Looking at the role of ODeL teachers specified in the subsystem, these configurations are directed towards the pedagogical, technical, and social aspects.

Student support subsystem

There are two categories under one sub-theme for this subsystem (see Figure 5). It is worth noting that the researchers only worked on a few codes when analyzing this subsystem. This may be due to the smaller representation from the focus of this subsystem— students—compared to other stakeholders.

Figure 5

Thematic map of the student support subsystem



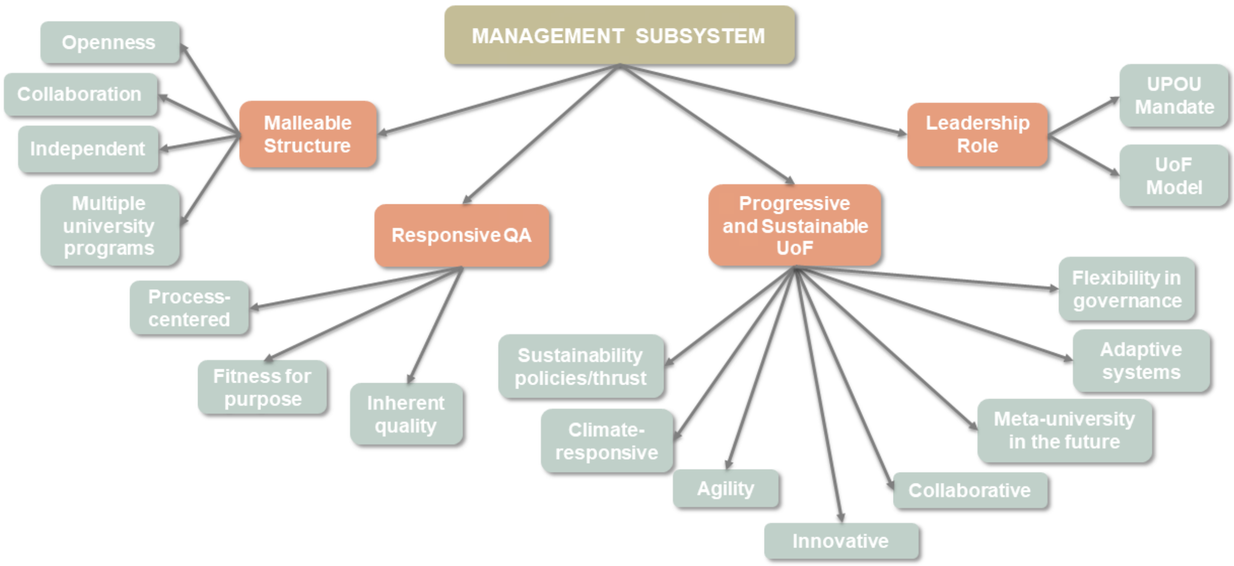
Generally, this student support subsystem was visualized to be responsive and effective. The researchers were able to create this sub-theme from the dominant categories of strengthened and analytics-based student support.

Management subsystem

Much of the discourse about the UoF brings about implications to the management subsystem, which acts as the "integrator" of all the other subsystems in an ODeL institution. Figure 6 shows that four (4) sub-themes have been distilled from the codes under this subsystem. It stresses that going beyond traditional boundaries while being guided by its roles and mandate produces a progressive and sustainable UoF.

Figure 6

Thematic map of the management subsystem



VRTD participants call for a malleable structure for UoF characterized by openness, collaboration, multiple university programs, manpower considerations, trifold-functions, among others. This entails the possibility that major functions of UPOU in the UoF will be forged by the dynamic environment where it belongs. Frequent mention of the UPOU's mandate and role in the UoF accounts for the sub-theme on the leadership role. If these qualities were possessed by or at least are being acquired by UPOU, then it positions itself as a leader in the pursuit of UoF. Another sub-theme is the need for a responsive QA system, albeit the question of its relevance in the UoF. The categories reveal that participants are hoping for a process-centered, fit-for-purpose, innovative, and inherent QA.

A progressive and sustainable UoF, as verbalized by the participants, includes concepts such as meta-university and pluridisciplinarity. Undoubtedly, when these concepts are adapted to practice, it pushes towards the direction of the unexplored concepts of UoF.

Recognizing this shift will then lead to major changes. In relation to the elements of the management subsystem, needs assessment and prioritizing will be influenced by a responsive QA. Monitoring and evaluation are necessary for a responsive QA and progressive and sustainable UoF. Lastly, policymaking will play an important role in terms of molding a malleable structure.

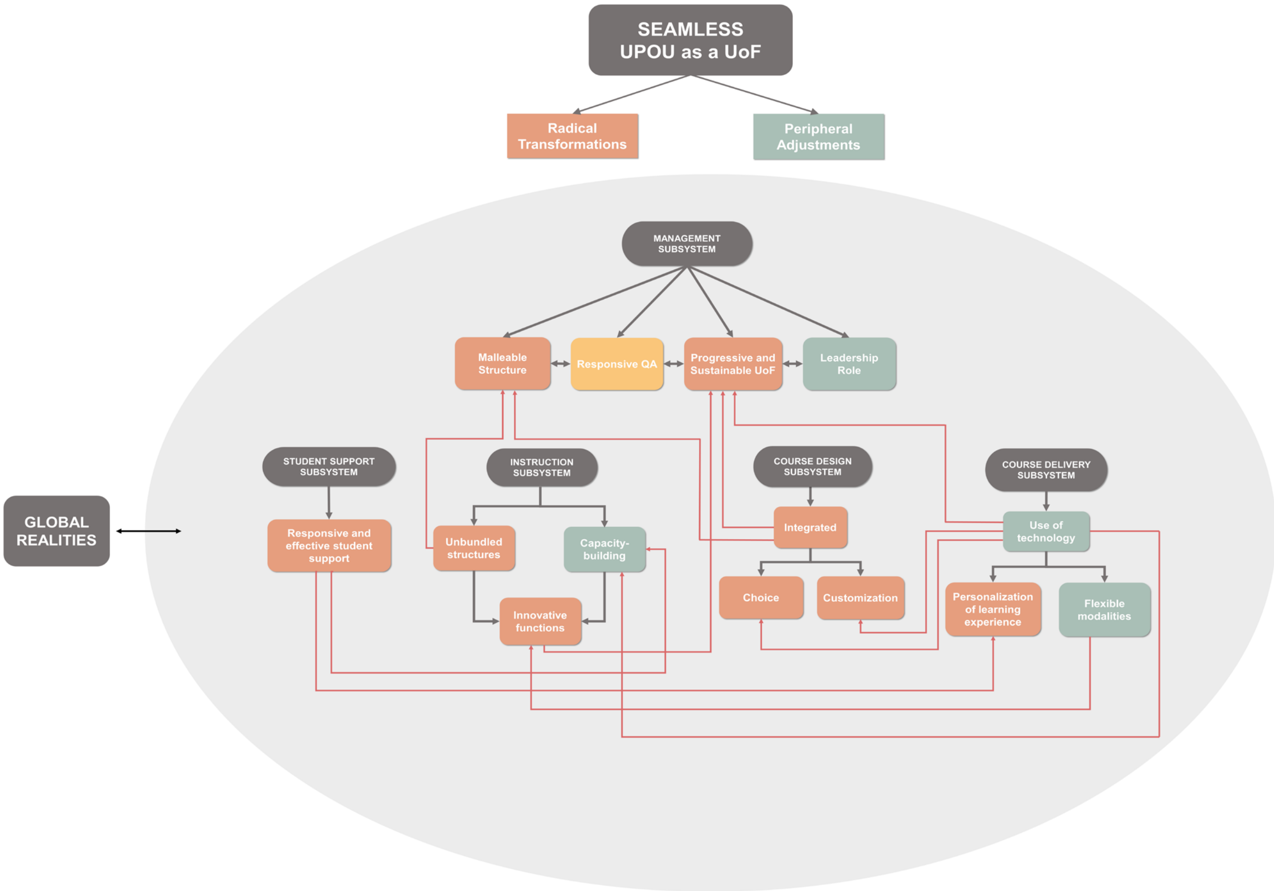
Themes

In efforts to answer the general research question, the researchers reflected on the surfaced sub-themes. Previous discussions point to a vision of flexibility and responsiveness. Thus, an overarching theme and two themes were produced from further abstractions.

Figure 7 presents the superimposed sub-themes, themes, and overarching themes into the ODeL subsystem considering the guiding framework (see Figure 1).

Figure 7

UoF configuration of the UPOU



In the course design subsystem, the sub-theme "integrated" also constitutes the "malleable organizational structure" sub-theme, where collaboration and openness are central, envisioned in the Management subsystem. Lastly, this integration provides another step towards becoming a "progressive and sustainable UoF." On the other hand, both the sub-themes of "choice" and "customization" reflect the emphasis on the "use of technology" found in the course delivery subsystem. As previously discussed, the former sub-themes depend on the technologies maximized in the University.

Analyzing the course delivery subsystem, "flexible modalities" imply that "innovative functions", such as mentoring, are encouraged and taken up in the instruction subsystem.

Integral to having a responsive and effective student support system are mechanisms to prepare students for "personalization of learning experience" and enable ODeL teachers to guide and facilitate the students' learning process.

In terms of the instruction subsystem, the proposed unbundled structure would require corresponding modifications to the malleability of the structure. Capacity-building on the use of technology in delivery learning is also being suggested. Innovative functions channel and inform a progressive and sustainable UoF under this subsystem.

Under the management subsystem, responsive QA is highlighted to be an umbrella covering all aspects (sub-themes) of this UoF configuration. This emanates from the process-based and largely intrinsic notion of quality proposed by VRTD participants.

Radical Transformation and Peripheral Adjustments

The two emerging themes were radical transformation and peripheral adjustments. Both refer to the different ways in which the UPOU can metamorphose into a UoF, emanating from the VRTD discussions. The latter asserts that the included sub-themes pertain to minor changes that UPOU must undertake to transition to a UoF. Use of technology, flexible modalities, capacity building, responsive QA, and leadership role need only be emphasized, improved, and strengthened. These imply that UPOU should maximize available and better technologies to allow a multimodal course delivery.

Consequently, UPOU staff performing teaching, research, public service, and administrative duties should have enough opportunities to develop their digital know-how, among other relevant skills necessary to build and sustain a future-proof university workforce. All these peripheral changes are expected from UPOU with its leadership role in ODL in the country. As such, these peripheral adjustments are sufficient conditions for the UoF configuration of UPOU.

On the other hand, radical transformation houses most of the sub-themes identified. This theme pertains to the overhaul of existing practices and processes to foster an enabling environment, making room for the envisioned revolutionary changes. The changes are claimed to be revolutionary because the visions established in the sub-themes question current dogmas. Specifically, advocating for unbundled structures and innovative functions in the instruction subsystem would mean scrapping tenure and de-loading faculty members while addressing the concern of limited manpower. Offering choice, customization, personalization, and effective student support will entail major changes in technology adoption and how the University engages with its stakeholders and vice versa. This is especially crucial for the student body and the way the University supports its unique learning needs. Finally, envisioning a malleable organizational structure to host a progressive and sustainable UoF will require revamping current rigid and residential-based systems. Hence, the VRTD participants deemed these radical transformations as necessary conditions to rethink and retool UPOU as a UoF.

Seamlessness

The concept of seamlessness surfaced as an overarching theme from the VRTDs. The word "seamless" pertains to "smooth and without seams or obvious joins" when taken literally (Merriam-Webster, n.d.). The concept is used to suggest continuity but not pertaining to an extension of current practices and processes. Instead, the researchers meant to explain the idea in which a free-moving and beneficial exchange happens effortlessly.

Using the concept of seamlessness to configure the UPOU as the UoF implies that virtually no boundaries exist within the University or beyond it that may compromise this continuity and harmony, whether that be political, economic, and/or social. In becoming a UoF, a seamless UPOU is envisioned to be permeable and porous enough to be equal in prestige and purpose with its surroundings. Otherwise, the subsystems, taken individually and as a whole, may not truly transform into a UoF. Thus, UPOU will have to level itself with the rest of society—its beneficiary—to effect the changes necessary to thrive in the future. Any HEI should put an end to privileged seclusion if they wish to remain relevant in the future (Salmon, 2019).

For instance, the University should partner with the industry, not only for employment opportunities of its students, but also to align program curricula and program packages with the emerging needs of the time and ensure that technologies are exhausted for the benefit of its students and staff.

Additionally, this overarching theme underpins the recurrent mention of uncertainty when VRTD participants talk of the temporal future. While trends and disruptions can give indicators as to what and how the future will look like, it can never be fully known. As such, the sub-themes refer to an ODeL system agile and resilient enough to handle the vague yet definite reality of uncertainty. Consequently, seamlessness is also evoked to put forward the idea of a minimally structured, if not amorphous, UoF. Rigid structures are simply boundaries—divisions—in a seamless UoF with mechanisms ready, flexible, and resilient enough to respond to disruptions. It has been suggested that a highly rigid structure cannot exist in the dynamic educational landscape of the future (Bridges, 2000; Milian & Davies, 2020). This rigidity has proved detrimental to unexpected disruptions, with the Covid-19 pandemic as a case in point. Even ODeL institutions such as the UPOU had to reorganize previously fixed matters (e.g., academic calendar) to accommodate learners serving at the frontlines of the pandemic. Hence, a seamless UPOU is configured as a way to embark on uncertain futures.

Rising to the UoF Challenge

In conclusion, IR 4.0 and Educ 4.0 are expected to continue driving changes in higher education, specifically, in ODeL. Flexibility, sustainability, collaboration, and technological use are some of the key characteristics of the envisioned UPOU in the future. The VRTD participants stress the need for a seamless UPOU either through peripheral adjustments or a radical transformation in becoming a UoF.

The authors recommend that the University begins with an assessment of its priorities, policies, and structures. Identifying these are crucial to dictate the course of the University towards becoming a seamless UoF. This step will also define the configuration of its subsystems, according to how the VRTD participants envisioned UPOU as a UoF, which this study discussed in depth.

To some extent, UPOU has initially responded to the calls for UoF. The initiatives below were undertaken by the University and are now part of the UoF configurations.

- University-level discourses on the openness of open universities (e.g., open curricula, open admission) in 2012 as captured in the 2017 book publication, "Conversations on Openness,"
- Pilot implementation of the Independent Learning Track, and
- MOOCs' universal accessibility enabling learners to choose based on their learning style (see https://model.upou.edu.ph/)

On the basis of thematic analysis and systems design, these are the areas that need to be looked at as the University envisions the future:

1. There will be a greater focus on reconfiguring the program/course curriculum to accommodate changes in the course design and delivery (e.g., independent learning will not be bound by timelines/cohort).
2. The role of UPOU in the UoF must be clarified, agreed upon by, and communicated to its stakeholders in order to carry out the vision of a UoF.
3. In terms of instruction, UPOU has existing capacity-building initiatives yet these need to be strengthened.

4. In terms of openness in pedagogy, while this is being recognized, its extent should be further explored as the meaning of openness in the educational context changes over time.

While this study is UPOU's configuration, the results can be used as a roadmap, or simply put, an informed vision for other educational institutions to conceptualize and contextualize a UoF. Educational institutions can refer to the following considerations in conceptualizing UoF. It should be: (1) aligned with the institutional vision, mission, and goals as institutions have its unique role, (2) contextualized based on the institution's model to create a holistic conceptualization, (3) aligned with the current initiatives and future conceptualization to determine gaps that would inform the strategic direction the institution should take, and (4) participative, in nature, as UoF will require peripheral and radical changes hence, it is important to engage the institution's constituents/stakeholders.

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Appendix A

Coded recording units into categories and themes

Sub-theme: Peripheral Adjustments		
Recording Units	**Descriptive Code**	**Category**
Course Delivery		
In the future, Universities will now provide options on how students would like to learn: physical, online, or blended. As more students opt for online classes, there is no longer a need in expanding the infrastructures of their campus.	Multi-modal	Flexible Modalities
If you'd look across the outputs, you will see that quite a number of groups have mentioned automation–-automation of academic processes and teaching processes	Provision of multimodal learning	Use of Technology
Management Subsystem		
Even the usual/common framework for quality assurance for technology-enhanced and technology-enabled courses and programs only look at the input but not so much on the processes as a result of delivering instruction. The call here is for us to take another perspective in a quality education despite our efforts in configuring the university of the future.	Process-centered quality concepts	Responsive QA
In terms of our statement, UPOU as a university of the future in terms of quality, we say that quality shall be inherent in all aspects of the university including teaching, learning, research, public service, and administration. *So dapat, kasama na talaga siya don, hindi na natin siya kailangan pa* __[inaudible]	Inherent quality in all operations of the UoF	

Recording Units	Descriptive Code	Category
Management Subsystem		
I think it is also important to have this bottom-up approach. We need to know what's going on in the ground level. What's going on with our student's mind, with our staff, faculty, with everyone. Yes, of course, the top can guide, can say—these are the things and the visions of the university—but somewhere, somehow, the top and the bottom should meet.	Participative/consultative quality assurance systems	Responsive QA
I think, that should now define *yung* quality *na sinasabi natin*. I think, *maganda yung inano [sinabi] ni* [redacted]. *Yun pala yung* term *non,* "fitness for purpose". I would subscribe to that conceptualization of quality *kase hindi ka naka-fix duon sa ano..*we have several rooms for improvement and we can really see the dynamics of what we are doing	Fitness for purpose as conceptualization of quality in UoF	
Ang UPOU will play a big role *sa pag-lead* ng other universities in the future considering our mandate sa R.A. 106050 *na tayo ang magaassist sa* other universities in developing their courses, delivering online yung mga courses	UPOU is mandated to be the UoF	Leadership Role
With this shift, UPOU is in a position to lead the way. We are the oblation of this shift: we are needed to outstretch what we know as we are the ones setting the benchmark and selflessly share our resources and expertise to unlock the optimal way for other Universities to chart the future.	UPOU as a model and lead for the UoF	

Sub-theme: Radical Transformation		
Recording Units	**Descriptive Code**	**Category**
Instruction Subsystem		
Something like that. It will probably affect the practice of the faculty tenure. Even now here at UP, the kind of talk that we have in terms of engaging a people who will be doing the work in the university--doing the publication, doing the teaching. I think, the trend, if my observation is correct, is also towards short-term engagement and in terms of engaging experts to work on specific projects, I think there is also that kind of trend happening now at the university.	Short engagements for unbundled role of academic staff in the future	Unbundled Structures
Because if we are looking at providing lifelong learning opportunities, then probably we will be engaging more lecturers, more of those practitioners in the industry to tandem with those who can theorex, who have the basic training in disciplines--in engineering, for instance	Industry-affiliated lecturers in the UoF	
Hindi lang po delivery, also we are open in terms of pedagogies. We are not limited to the instructional model of education, where the instructor is the sage on the stage, *sabi nga nila no. Hindi tayo yung ganoon eh, tayo parang mas importante pa nga yung learners sa atin, di ba?* So we are open to these different types of pedagogies, we're not constrained to one.	The UoF should be known for openness in pedagogies	Innovative Functions
So the necessary skills and values can also be provided by the university, or the University of the Future through a mentoring system. So while in the... so they are in the university, they are mentored as students but hopefully when they graduate they should be... they should also be able to mentor somebody else in their community to achieve sustainability where they are. And so therefore the application of knowledge maybe through innovations or sustainability innovations.	Mentoring as a sustainable teaching approach	

Recording Units	Descriptive Code	Category
Instruction Subsystem		
Another thing that's related to that, that I've mentioned in the past, that we can use when we're trying to reflect on the trajectory of this is probably *yung* academic genealogy ng mga people in that discipline. I've mentioned this before to my colleagues in [redacted], the idea of the academic tree. When you advise someone, whether their dissertation *ganoon,* you impart your knowledge to them and you impart your methodologies, *yung* style *ng pag-iisip*, even your perspectives, *sa kanila.* Soon they will develop their own but they would also adopt part of yours. *Makikita mo na* through the generations, *nadadala pa rin yung mga* certain thoughts in the past. That's exactly what [redacted] talked about earlier, when it comes to the genes, and obviously it will get passed down eventually. Probably pretty much the same when it comes to discipline, so the idea of this website, academicfamilytree. org yata siya, there are different fields *pero parang walang direct sa atin dito, parang wala rin akong mahanap na* colleagues *dito bukod kay* [redacted], *siya lang yung nakita kong colleague dito* from UPOU. *Pero* the idea that, if you want to see what happens in the field, maybe we can look at *kung sino yung pinakamaraming in-advise and yung in-advise ng in-advise niya.* Or *sino yung* adviser *mo, at sino yung* adviser *ng* adviser *mo*. And when it comes to the way that they think, maybe yung ETIC and EMIC *nila*, you would be situated similarly, *dadami yung mga* people in that quadrant, and that would inform what the discipline would be like in the future.	Academic genealogy as basis for future disciplines	Innovative Functions

Recording Units	Descriptive Code	Category
Course Design Subsystem		
I think IL, I consider it as part na of the processes in the university of the future. Students can enroll anytime and they can also finish their program anytime. I think that should be the way that we should have to go given the high demand of work forces not only in the country but even in other countries.	Independent learning (IL) pathway	Choice
...actually *isang ano siguro* example *parang pwede natin maconsider* its a change in a way we do things, *yung IL natin yung* independent learning I think *hanggang* university *lang sya* and we were able to implement *yung IL*. On the other hand, *nandon lang parang naconstrained lang din siya don sa* existing policies when it comes to administrative side *nung* implementation but on the academic side we were able to do that and in fact *kung maayos lang siguro yung* administrative side *ng* implementation *baka* its a really good flexibility *kasi* you can just imagine the student can actually finish the entire program earlier *don kaysa sa* expected because the student can enrol anytime can take the final examination anytime and so on and complete the course requirement anytime and I think that's one innovation even within *yung* context *natin nagawa natin* just within the university despite *yung* rigidity *nga ng* policies *natin, kailangan lang yung sa* administrative side *na yon mayroon ding kaakibat na* flexibility to make that approach work efficiently *sa programa natin.*		
It's like a menu-type and the decision coming from the learner who is an active learner in terms of deciding and determining the pathway that he wants and the institution has mechanism to support that, and also so doing what will remain constant of course	Menu-type curriculum	

Recording Units	Descriptive Code	Category
Course Design Subsystem		
...its teacher-centered *ito* being learner-centered you know what skills you need and what's skills you can make use of and then you pick from the menu and you make your own curriculum there are institutions that do it right now *pero tayo parang pipedream pa* right now but that's other people do	Menu-type curriculum	Choice
Sa ngayon given *nga yung* distribution *ng mga studyante natin*, I don't know how the university should respond *doon sa* information *na ito na* more than 75% of our students are located in these areas *yung nakita ko lang ngayon na pwedeng marecommend siguro is baka dapat* at the start ng class *andon na yung* course materials *para madownload na nila* before *pa dumating yung mga* emergency cases like *yung bagyo hawak-hawak na nila yung mga materials nila* at the same time *pwede sigurong magbigay ng mga options* in terms of learning activities in case *maapektuhan ka ng bagyo ito yung gagawin mo* or in case *may* earthquake *na mangyari ito yung gagawin mo pero* that should be put in place before *pa nakaenrol ang estudyante para* at least *andon kung nandon na sya nasa loob na sya ng kurso alam nya na ang gagawin nya* in case of emergency *na mangyayari.*	Offline program packages as a climate-adaptive strategy in the UoF	
So probably *ang gagawin kung ieexpand mo* and you allow students to have a limited sense of PLE *lahat nung- halimbawa isang kurso* starting as from the center as a network of connected resources *lahat ng pwedeng makonekta halimbawa isang* courses course *dadaan muna siya sa isang curation hindi lang* curation in the sense *na tinitignan mo* whether that is fit with your particular course and particular program *iccredit na ba yan? May credit equivalent na ba yan? Ibig sabihin yung mismong program pati yung outside yung kanyang* resources *isusubject niya na* through possible prevalidation and you can come up...	Personalized Learning Environments are within and beyond the university	Customization

Recording Units	Descriptive Code	Category
Course Design Subsystem		
... with another assessment with simple assessment through post-validation once the student had supposedly *halimbawa* join a community *ano yung* added value *non sa* community so at the same time *tinitignan mo kung* if you have a robust competency of framework *siguro at hahanapan mo siya* where you can credit that dun pumapasok yung issue ng microcredentials.	Personalized Learning Environments are within and beyond the university	Customization
Can we have a more differentiated response to people or learner needs? How can we adjust the curricula to meet their learning needs? Maybe at this point, it's best to turn to science fiction, narratives around the future. What's an ideal in the future that people learn? Is it like you wake up every morning and you go to Siri or Google and you say, "Today this is what's happening to me...'*Eto ang problema ko sa buhay ko...* This is what I'm interested in… This is how I'm different from this week...What should I learn today"? And then you know, *parang* there this whole new, "Okay, well, today you have a difficult internet access, but we have arranged a bunch of activities that you can take instead". Talking about a singular institution of the future is very very difficult. Briefly, there is no average UPOU student. How can we adjust the curriculum to meet learner needs? Well, if you're willing to follow this through then every single curriculum, every single activity will be different and then, we have to think about assessment in different ways. Then, we have to think about summative and formative assessment in a totally different way.	Individualized learning environments	
We have the course delivery next. One way to discuss the gig economy is adaptive learning–-the use of AI to move students up and down based on analytics-based assessment.	Analytics-based assessment	

Recording Units	Descriptive Code	Category
Course Design Subsystem		
What kind of college degrees shall we offer? In November, I already mentioned the pluridisciplinary degrees to be the new normal. Probably, an example can be a degree in Computer Science will also have courses on Physiological make up of the body, on Psychology, even on Anatomy, on environment, so that the future of computing technologies will not just be about the technology itself, but taking into consideration the user and the environment. Again, the idea is for us to consider Future proof degrees that will provide that disciplinal knowledge which can serve as raw materials from which new knowledge or even innovations can be developed	Pluridisciplinarity to future-proof degrees	Integrated
So application of theories to achieve sustainability. So our students must be able to understand the sustainability issues and challenges, and they should see be able to see the interconnection of problems in the society. And so the way to train the students, is for them to see the interconnection of their discipline to all other fields.	Incorporation of sustainability in curriculum	
In order to reduce the demanded skills in the market, universities would try to develop programs and courses that would address the demand in order to reduce the gap in the industrial process and also *yung pinoproduce* ng university.	Labor market-driven programs in the UoF	
Management Subsystem		
In terms of what the UPOU can do, we can talk about that specifically. In terms of the university of the future, it will be inevitable that there will be more partnerships in the industry because we will be engaging nga with professionals. We are trying to make our courses as relevant as possible.	Industry collaboration in teaching & learning	Malleable structure
But we might consider them as we look at UPOU as - maybe - the university of the future within or without the UP System.	Independent UPOU as a UoF	

Recording Units	Descriptive Code	Category
Management Subsystem		
In the process of conceptualizing this continuing education program under [redacted] I actually have a personal quest, I really want to find out how open are we and when it comes to openness how open are we how fast and how nimble can we actually be when it comes to proposing courses	Open and flexible organizational structure	Malleable structure
But then again *ang tanong*, although we can do things like in this side sa university but if you are going to link now to the other side wherein we are being governed by this highly structured and rigid policies of the university I think *dun medyo magkakaron ng* conflict *o problema. Yun yung itanong ko kasi kanina,* how far we should have to go to make UPOU as the university of the future.	Structural flexibility for UPOU as a UoF	
Actually *itong term ni* [redacted] *na pandiscipline*, it reminds me of another term, metatheory. So there's a class of theories, which is theorizing on theories and theoretical concepts. And I wonder now to what extent UPOU in the future could be, this sounds kind of weird, *pero* as kind of a meta-university where it reflects quite deeply on a quite theoretical level on everything else that is happening in the research arena in the Philippines. And you can use *yung* different lenses, whether it's from the lens of information and communication, or from management and development studies, or education around that.	UPOU as a meta-university in the future	Progressive and sustainable UoF
The traditional university with all our heritage and tradition, how do we adjust? And specifically, how do open universities like us adjust to that situation kasi the… as open university, our philosophy has always been defined by openness. And this is something that is more important in the future. But the thing is, the socio-economic, political and environmental traditions also define what openness means to us in different stages or eras of our time. The way… yung ating economic,...	Adjusting the concept of openness according to the present context to accommodate the future	

Recording Units	Descriptive Code	Category
Management Subsystem		
...social political conditions define what we teach and how we teach. When we move from the industrial model *na* traditional way of distance education to ODeL, we still work for openness *pero yung* implications to openness *nagbago. Iba-iba yung* implications to equity, to access, to inclusiveness, to diversity. Now, going to the future, *ano ngayon yung magiging* implications *niyan* to openness? *Kasi* it's a matter… we need to talk about… not only about how we're going to teach, but how we're going to teach in a more open way, in an open way, and what does openness means to us in a post-industrial era?	Adjusting the concept of openness according to the present context to accommodate the future	Progressive and sustainable UoF
I also wonder to what extent in the future we will have to rethink sustainability. In the future, as we face issues around the climate and the environment and as time becomes more of a limited resource, every little step or every action that should be made would be done with the consideration to how it impacts or disrupts entire systems. Do we really need to print this label? Again, I'm back to this whole paperless future [inaudible]. Do we really need to sign this paper? Do we really need to print this label? Do we really need to approve this one thing? I think we really need to *parang* who says to anticipate what will be the conflicts, what are the threats, what are the culture wars that will be in place in the future? Because there will be culture wars, there will be divisions. And anticipating those divisions, anticipating those conflicts can help us position ourselves better as universities of the future, or the future, and in the future.	The UoF as a responsive, sustainable, and adaptive system	

Recording Units	Descriptive Code	Category
Management Subsystem		
...because of the changing times, changing technologies. We also need to adapt and change into something new and something better, so we need also to be resilient. So we have be sustainable but we have to be resilient at the same time. So *sa baba* I can see there's the identification, and maintenance of best practices. And there should be also flexibility in times of changing times.	Flexibility and resilience with changes	Progressive and sustainable UoF

Simulation-Based Instructional Materials on Central Dogma of Molecular Biology

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Abstract

The essence of Genetics lies in the understanding of the concepts of Central Dogma of Molecular Biology. Although these ideas are fundamental to the field, they are notoriously difficult to understand and visualize. While simulation-based instructional materials are found to improve the teaching-learning process in science education, little has been done to assess their effectiveness in teaching and learning the concepts of Central Dogma of Molecular Biology. Hence, this study aimed to examine the effectiveness of simulation-based instructional materials towards the learning performance of Grade 12 learners on the concepts of Central Dogma of Molecular Biology. This study utilized a mixed-method approach. Adapted computer simulations were properly integrated in the developed session plans. Pretest and posttest were conducted, and results showed that the learners demonstrated improvement from approaching proficiency to advanced mastery level on the concepts of Central Dogma of Molecular Biology. Furthermore, it was revealed that the learners' pretest and posttest mean scores on the concepts differed significantly (p<.05). The result of the semi-structured interview revealed that the learners were engaged in experiential learning using simulation-based instructional materials.

Keywords: *Central Dogma, computer simulations, genetics, instructional materials, Molecular Biology*

Introduction

The COVID-19 pandemic has ushered educational institutions across the globe to new technology-based modalities of instructional implementations (Dukes, 2020; Mahaffey, 2020; Masoud & Bohra, 2020). The changes in the educational landscape posed constraints to teachers with the emergence of new technological challenges and instructional strategies (Sunasee, 2020) in teaching science concepts that have highly abstract mechanisms (Arrieta, et al., 2020; Huang, 2020), such as Genetics. Genetic education is considered necessary in schools to develop learners who can understand issues on the applications of Genetic technologies (Change & Anderson, 2020).

However, the essence of Genetics lies in understanding the concepts of Central Dogma of Molecular Biology. Understanding this topic at the secondary level is essential and a precursor to other higher concepts in biology as it connects biological processes happening at the cellular and organismal levels (Picardal & Pano, 2018). While this topic is regarded as core to the discipline, many teachers and learners are facing the burden of understanding its highly abstract concepts. Hence, it remains difficult to teach, and least mastered among teachers and learners, respectively (Wright et al., 2014). Many authors pointed out that this is due to the complexity of the topic's underlying concepts that are not available for direct observations (Change & Anderson, 2020; Picardal & Pano, 2018; Reddy & Mint, 2017).

Consequently, science education in the Philippines has shown downward trends as observed in national and international standardized assessments (Adarlo & Jackson, 2017; Department of Education, 2020). Rivera (2017) posited a need to develop robust teaching pedagogies to elevate the country's scientific literacy by devising innovative teaching techniques, such as integrating technology-based instructional tools in the teaching-learning process. Likewise, Huang (2020) pointed out that using appropriate technology-based instructional materials to support the teaching-learning process in the COVID-19 pandemic is deemed necessary to mitigate its educational constraints.

Simulation-based instructional materials are commonly used in science education to promote active learning. These learning materials are found to scaffold learners to understand concepts that require higher abstract thinking by providing linkages between what is heard and what is seen (Olga et al., 2020). More senses are involved; hence, learners become more engaged in deep learning that empowers understanding as opposed to surface learning. Despite the advantages offered by simulation-based instructional materials in science education, many teachers are encumbered, and have no bold attempt to integrate these tools in their teaching pedagogies. Anoba and Cahapay (2020) pointed out that the inaccessibility of resources and the lack of competence and confidence in the proper utilization of technology are among the reasons. Hence, these available simulation-based instructional materials are not maximized, and little has been done to assess their effectiveness in teaching and learning the concepts of Central Dogma of Molecular Biology. This prompted the researchers to conduct a study to assess the effectiveness of simulation-based instructional materials on the learning performance of Grade 12 learners in Central Dogma of Molecular Biology.

Objectives

This study aimed to assess the effectiveness of simulation-based instructional materials on the learning performance of Grade 12 learners in Central Dogma of Molecular Biology. Specifically, this study sought to answer the following questions:

1. What are the mean mastery level scores of the learners in Central Dogma of Molecular Biology before and after the conduct of the study in terms of: a) DNA Replication, b) Transcription, and c) Translation?
2. Is there a significant difference in pretest and posttest scores of the learners in Central Dogma of Molecular Biology in terms of: a) DNA Replication, b) Transcription, and c) Translation?
3. What are the attitudes of the learners exposed to simulation-based instructional materials?

Review of Related Literature

Simulation-Based Instructional Materials

With science and technology developing rapidly, science education is now presently taught using several methods, techniques, and models to improve learning. DeCaporale-Ryan et al. (2016) attest that helping learners build representations of complex structures by integrating words and pictures is one way to improve learning. Moreover, this method has aided the development of a unique category of immersive educational tools called simulation-based instructional materials (Kutz et al., 2016).

Gruler et al. (2019) define simulation-based instructional materials as artificial representations of real conditions. These are instructional tools that can provide learners with a safe and supportive setting and allow them to practice more abstract and critical thinking skills while eliminating any danger through active learning. Compared to traditional classroom discussions, these tools can also generate their interests, providing insights through experiential learning (Juan et al., 2017).

Likewise, Cant and Cooper (2017) established that simulation-based instructional materials could develop and improve learners' critical, strategic thinking, and creativity skills. Prior studies have also emphasized that simulations are effective in creating scenario-based environments for learners to interact and apply their knowledge and skills to deal with issues of the modern world, and for teachers to accomplish their objectives (Angelini, 2016; Becker & Hermosura, 2019; Juan et al., 2017; Kutz et al., 2016). Cai et al. (2016) attest that these simulations enable learners to experiment interactively with concepts' essential theories and applications. Furthermore, they can provide reliable and instant feedback and give learners opportunities to try out different variables and instantly evaluate their ideas for accuracy.

On the contrary, the disadvantage of simulations is that they restrict learners' ability to explore new information, which is determined by the number of simulations accessible for a given subject. According to Efe and Efe (2011) and Lameras et al. (2016), the utilization of computer simulations greatly depends on their availability and compliance with curricula, and teachers' efficacy in using them. Recent studies have shown that the characteristics of these computer models (e.g., technical, content, instructional qualities) must be emphasized in order to ensure that the learning, imagination, decision-making, coordination, reasoning capacity, and initiative of the learners are all positively impacted (DeCaporale-Ryan et al., 2016; Gunda & Dongeni 2017; Mceneaney, 2016; Olga et al., 2020).

The Learning Process in Simulation-Based Instructional Materials

The learning process is not guaranteed through the knowledge and intelligence of the teacher alone. According to Lameras et al. (2016), teaching must be coupled with appropriate selection and use of instructional resources and teaching strategies. Therefore, in order to optimize the learning process, appropriate and effective teaching style and instructional materials such as computer simulations should be planned consciously.

As cited by Pugh et al. (2020), John Dewey posited that continuous teaching by learning through doing leads to changes in learning. Likewise, David Kolb, as cited in Reshmad'sa and Vijaya Kumari (2017), noted that reflection is an important aspect of the learning process and that learners must consciously participate in the process through experience.

Similarly, Juan et al. (2017) commented that simulation-based instructional materials are tools that can engage learners in experiential learning. By using computer simulations, learners are actively involved through participating in realistic, dynamic, and complex situations. Pugh et al. (2020) emphasized that in order to remain involved in learning, learners should focus on what is happening before and during an activity. When learners take a thoughtful approach focused on actual or virtual knowledge, it can lead to increased strategic thought and, as an effect, a stronger comprehension of concepts (Cant & Cooper, 2017).

According to Kolb's (1984) experiential learning theory, learners learn in four stages: *concrete learning,* where they have a new experience; *reflective observation*, where they reflect on their experience personally; a*bstract conceptualization*, where they form new ideas or adjust their thinking based on the experience and their reflection on it; and *active experimentation*, where they apply new ideas to the world around them. Kolb argues that effective learning is seen as the learners go through the cycle, and they can enter into the cycle anytime (Reshmad'sa & Vijaya Kumari, 2017). As a result, the learners can improve by problem-solving and achieving a higher understanding of the concepts. On the other hand, Pugh et al. (2020) stressed that the human learning method could involve a variety of time periods based on what is to be processed and how rigorous the process is.

The Central Dogma of Molecular Biology

The Central Dogma of Molecular Biology is a vital topic in Genetics. It is the key to understanding how the deoxyribonucleic acid (DNA) information is used to produce functional proteins. Understanding the Central Dogma of Molecular Biology at the secondary level is essential and a precursor to the higher concepts in biology and other fields of Science (Wright et al., 2014) to be able to connect the process to the activities happening at the level of cells, organs, and organisms (Newman et al., 2012; Van mil et al., 2013).

Accordingly, Change and Anderson (2020) reported that although learners have correctly used the terms such as transcription and translation processes, they still failed to explain the canonical model of DNA to RNA to protein. Molecular basis of inheritance is cited to be a difficult topic even for the biology senior learners (Picardal & Pano, 2018) because of the underlying concepts that are at the molecular level and are not available for direct observations of the learners (Change & Anderson, 2020; Reddy & Mint, 2017; Wright et al., 2014).

Likewise, connecting the ideas of genes and their protein components, as well as protein products and phenotype, has proven to be especially difficult for learners (Wright et al., 2014). One reason for this challenge is that Genetics definitions span many organizational layers (Change & Anderson, 2020) and require learners to comprehend that the physical constructs of DNA comprise information (Picardal & Pano, 2018). Learners must first consider the interactions between DNA, mRNA, and proteins, and then those between protein functions and diseases, in order to understand the principles connected with the Central Dogma of Molecular Biology and, finally, Genetics. Learners must consider why the genetic code uses three consecutive nucleotides for each codon, why start and stop codons are used, what promoter regions are for, and how genetic mutations influence phenotype, induce disease, and form the basis for variation (Change & Anderson, 2020). However, these ideas were observed to be challenging for learners to understand.

To date, several recommendations have been made on how to promote learning of the subject more effectively. For instance, some activities have included learners manipulating different molecular components and processes utilizing computer animations (Marbach-Ad et al., 2008; Rotbain et al., 2008), while others have involved learners physically modeling the processes under review (e.g., Marshall, 2017; Takemura & Kurabayashi, 2014). Takemura and Kurabayashi (2014) used a role-playing game with physical props to teach transcription and translation, while Marshall (2017) used a paper-modeling activity to replicate molecular processes with undergraduate Genetics learners. These studies highlight that in order to understand abstract ideas, learners should be engaged with molecular entities as frequently as possible through experience (Picardal & Pano, 2018).

Conceptual Framework

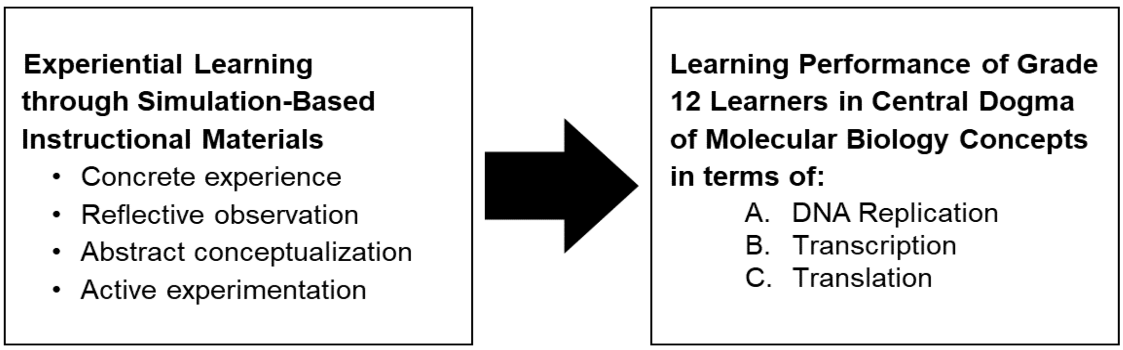
This study was anchored on the learning theories and models of John Dewey's Learning by Doing (Dewey, 1997), and David Kolb's Experiential Learning (Kolb, 1984). These models are interrelated and structured on concrete experiences through hands-on learning. Hence, this study validated the effects of experiential learning, a broad umbrella term used to cover the wide variety of learning by doing approaches, through simulation-based instructional materials on the learning performance of the Grade 12 learners in Central Dogma of Molecular Biology.

Kolb's experiential learning theory (Kolb, 1984) argues that learning works in four stages – *concrete learning* where a learner gets a new experience, *reflective observation* where the learner reflects on their personal experience, *abstract conceptualization* happens as the learner forms new ideas based on the experience and their reflection about it, and *active experimentation* where the learners applies new ideas to the world around them and to assess if there are any modifications to be made. Kolb (1984) posits that learners have their own preferences on how they will enter the cycle of experiential learning, and these preferences boil down to a learning cycle. As a result, learners practice critical thinking, and eventually, can achieve a higher level of understanding of the concepts.

As shown in Figure 1, the elements of experiential learning through simulation-based instructional materials make up the study's conceptual framework.

Figure 1

Conceptual Framework of the Study



Methodology

Research Design

This study utilized a mixed-method approach. The quantitative phase of the study used the pretest and posttest design to determine the learner's mastery level before and after applying the simulation-based instructional materials. For the qualitative phase of the study, semi-structured interviews were conducted in order to reveal the learners' attitude towards the simulation-based instructional materials. This is to examine and strengthen the quantitative data gathered on the effects and significant differences on the sample groups' pretest and post-test scores. One sample pretest-posttest design (Knapp, 2016) was specifically employed in this study. The feature of this research design is that the study is conducted in one (1) sample group only, and the measurements of the samples were taken both before and after the method was applied (Fraenkel & Wallen, 2000).

Research Participants

The participants of this study were the learners from one (1) section of the Grade 12 STEM strand of Notre Dame of Marbel University-Integrated Basic Education Department Senior High School. To ensure the containment of the data, and to avoid contamination and inconsistencies in the results of the study, the following inclusion criteria in selecting the participants were employed: (1) the participants must be enrolled in the Grade 12 STEM strand in the second semester of the school year 2020-2021, (2) any gender with no age restrictions were recognized as participants, and (3) the participants must be currently taking General Biology 2 subject.

Sampling Technique

The participants of this study were mainly selected based on the purposive sampling technique. It was a non-probability sampling technique in which the researchers carefully selected the sample with the assumption that each participant would be able to provide specific and rich data that are important to achieve the purpose of the study. Students from one (1) section of Grade 12 STEM were chosen as the study participants.

Research Instrument

For the gathering of quantitative data, the study used a Pretest-Posttest Questionnaire adapted from the study of Newman et al (2016). It was used to assess the mastery level of the learners on the concepts Central Dogma of Molecular Biology. The questionnaire consisted of forty (40) multiple-choice items covering the following sub-topics: a) DNA Replication, b) Transcription, and c) Translation. The reliability of the questionnaire was assessed by using the split-half method. Right answers were given 1 point and wrong answers were given with 0. The data analysis revealed that the pretest-posttest questionnaire had a Guttman Split Half coefficient of 0.992. This indicated that the questionnaire scale had a high level of internal consistency (DeVillis, 2003; Kline, 2005). The mastery level scores in the pretest and posttest of the learners on the concepts of Central Dogma of Molecular Biology were described using the scale in Table 1.

Table 1

Descriptive Rating of Learner's Mastery Level Scores on the Central Dogma of Molecular Biology Concepts

No. of Items			Percentile	Description	Interpretation
8	16	40			
6.41-8.00	12.81-16.00	33-40	81-100	Advanced	Very High
4.81-6.40	9.61-12.80	25-32	61-80	Proficient	High
3.21-4.80	6.41-9.60	17-24	41-60	Approaching Proficiency	Average
1.61-3.20	3.21-6.40	9-16	21-40	Developing	Low
0.00-1.60	0.00-3.20	0-8	0-20	Beginning	Very Low

Note. Adapted from "Conceptual Understanding, Attitude and Performance in Mathematics of Grade 7 Students* by Andamon, J. and Tan, D. (2018), *International Journal of Scientific & Technology Research, 7*(8), 96-105. https://www.researchgate.net/publication/327135996

For the gathering of qualitative data, the researchers used semi-structured interview guide questions adopted from the study of Ulukok, and Sari (2016) to reveal the attitudes of the participants exposed to the simulation-based instructional materials. The tool contained five (5) open-ended questions that revolved around the utilization of the instructional materials.

Development and Validation of Session Plans

The Department of Education curriculum guide was considered in preparing the content to be included in the session plans. The topic considered in the study was the Central Dogma of Molecular Biology. This topic was chosen and included in the study as it was cited to be a difficult topic to teach and learn by the teachers and learners, respectively (Knippels et al., 2005; Kozma et al., 2000; Lewis et al., 2000; Reddy & Mint, 2017). Furthermore, teachers of the subject suggested this topic because of more complicated mechanisms involved. The experience of the researchers also provided information that this was the topic found most difficult and with least mastered competencies. This topic involves DNA and RNA structures that were tedious to analyze and draw on the chalkboard and could be provided with a computer-simulation material.

After identifying and selecting the topic, session plans were developed and validated. Four (4) expert validators were asked to evaluate the developed session plans. The evaluation tool adapted from the study of Mercado (2020) was used. The tool contains three main criteria: (1) content quality; (2) technical quality; and (3) instructional quality. All of the criteria contained nine (9) indicators. A 5-point Likert scale shown in Table
2 was used to describe and interpret the validation results of the developed session plans. The means were calculated to evaluate the developed materials in terms of their content, technical, and instructional qualities.

Table 2

Rating Scale for the Developed Session Plans Validation

Rating Scale	Range	Description
1	1.00 – 1.50	Not Applicable
2	1.51 – 2.50	Strongly Disagree
3	2.51 – 3.50	Disagree
4	3.51 – 4.50	Agree
5	4.51 – 5.00	Strongly Agree

Note. Adapted from "Development of Laboratory Manual in Physics for Engineers," by Mercado, J. (2020), *International Journal of Science and Research.* https://www.ijsr.net/search_index_results_paperid.php?id=SR201002120011

The validation result showed that the validators strongly agreed on the content, technical, and instructional qualities of the developed session plans on Central Dogma of Molecular Biology.

Simulation-Based Instructional Materials Used in the Study

The simulation-based instructional materials used in the study were properly incorporated in the developed session plans. The LabXchange® Simulation Package on DNA Replication and Central Dogma developed by the Harvard Faculty of Arts and Sciences and funded through the Amgen

Foundation, Gene Expression Simulation developed by Colorado University's Physics Education Technology (PhET®) Project, DNA Interactive Simulation developed by Cold Spring Harbor Laboratory, and Holt's Central Dogma Simulations developed by Holt (2008), were integrated with the session plans to deliver the intended outcomes in teaching the Central Dogma of Molecular Biology. All the interactive simulation tools were adapted into English.

Data Gathering

Before the conduct of the study, the following were prepared and ensured: (a) development and establishment of the reliability of the Pretest- Posttest Questionnaire, (b) identification of appropriate simulation-based instructional materials anchored to the topic and curriculum, (c) review of resource materials and instruments to ensure the coherence of the competencies with the Department of Education (DepEd) – Curriculum Guide, and (d) development and validation of the session plans. The researchers initially wrote a permission letter explaining the purpose and nature of the study to the School Principal of Notre Dame of Marbel University-Integrated Basic Education Department Senior High School. Subsequently, a letter of invitation and the approved informed consent form were sent online to the participants and their parents to seek their approval. The goal and their participation in the research were also explained to them.

The identified participants were asked to answer the pretest using the Pretest-Posttest Questionnaire. The pretest was administered through Schoology® - the official learning management system of the school. The participants answered the test synchronously for one (1) hour. The test was given to gauge the mastery level of the learners in Central Dogma of Molecular Biology before applying the simulation-based instructional materials. The sample group went through ten (10) online teaching sessions based on the developed session plans. The official learning management system of the school - Schoology®, was used as the platform. The simulation-based instructional materials from LabXchange®, PhET®, DNA Interactive®, and Holt's® Simulations were used during the online teaching sessions. The researchers delivered the instructions, methods, and instructional materials to prevent external factors and bias. The delivery of instructions using the simulation-based instructional materials ran for one week. Two (2) hours of online teaching were administered per day, and one session was administered per hour. The same set of questions in the pretest-posttest questionnaire was administered for the posttest. The researchers administered the tests online.

The semi-structured interview was administered to the nine (9) identified participants from the sample group. The participants were requested to answer five (5) semi-structured interview questions online. This was to examine and strengthen the quantitative data gathered on the effects and significant differences on the participants' pretest and post-test scores. The date and time of the interview were scheduled based on the participants' convenience. The participants were coded as S1 to S9 to keep their identities confidential.

Data Analysis

The mean and percentage were used to determine the mastery level scores of the participants before and after the conduct of the study on the concepts of Central Dogma of Molecular Biology. The paired-samples t-test was used to determine the significant difference in the pretest and posttest scores on the mastery level of the participants on the concepts of Central Dogma of Molecular Biology. Meanwhile, the data gathered from the semi-structured interview were subjected to Thematic Content Analysis to reveal the learners' attitudes when exposed to simulation-based instructional materials. Verbatim data from the interviews were transcribed. Subsequently, the transcripts were analyzed to classify relevant sentences for further coding, involving sentences, terms, or long statements (Factor et al., 2017). The reliability of the qualitative data was ensured by sending back the initial codes together with the significant statements to the participants for checking.

This is to ensure that the codes generated include the real experiences of the participants (Birt et al., 2016). Related codes were clustered into categories (Saldana, 2009). Consequently, categories were synthesized in an overarching theme that later became instrumental in revealing the learners' attitude when exposed to the simulation-based instructional materials.

Ethical Considerations

This study complied with the ethical standards set by the Notre Dame of Marbel University. Furthermore, the study was conducted with the informed consent of all the participants. No sensitive information was drawn from the participants. The researchers strictly followed interview protocols before conducting the semi-structured interview and ensured that the participants and their parents approved the electronic informed consent form. The participants were assured that their participation would be private, confidential, and voluntary. The participant's identity would also remain anonymous. It was also emphasized to the participants that the gathered data from the semi-structured interview will be used purely for academic purposes only and shall be treated with the utmost confidentiality.

Results and Discussions

Pretest and Posttest Scores of the Learners

This study sought to determine the mean mastery level scores of the learners in Central Dogma of Molecular Biology concepts before and after the conduct of the study. The mean and percentage of the pretest scores of the learners on the Central Dogma of Molecular Biology concepts were computed. Based on the percentage values, descriptions were offered. The learners' pretest mean mastery level scores on the concepts of Central Dogma of Molecular Biology are presented in Table 3.

Table 3

Learners' Pretest Mean Mastery Level Scores on the Central Dogma of Molecular Biology Concepts

Concepts	No. of Items	Mean ± SD	Percentage	Description
A. DNA Replication	16	10.17 ± 2.46	63.54	Proficient
B. Transcription	8	3.81 ± 1.00	47.66	Approaching Proficiency
C. Translation	16	9.04 ± 3.15	56.51	Approaching Proficiency
Overall	**40**	**23.02 ± 5.82**	**57.55**	**Approaching Proficiency**

Note. 0%-20% = Beginning 61%-80% = Proficient
21%-40% = Developing 81%-100% = Advanced
41%-60% = Approaching Proficiency

The pretest result showed that, out of 16 items on the concept of DNA Replication, the learners obtained a mean mastery level score of 10.17 ± 2.46 or 63.54%. This implied that the learners were "proficient" in the concept of DNA Replication. On the other hand, out of 8 items on the concept of Transcription, the learners obtained a mean mastery level score of 3.81 ± 1.00 or 47.66%. This suggested that the learners were "approaching proficiency" on the concept of Transcription. Likewise, out of 16 items on the concept of Translation, the learners obtained a mean mastery level score of 9.04 ± 3.15 or 56.51%. This indicated that the learners were "approaching proficiency" on the concept of Translation.

Nevertheless, out of the total 40 items on Central Dogma of Molecular Biology concepts, the learners registered an overall mean mastery level score of 23.02 ± 5.82 or 57.55%. This revealed that the learners were generally "approaching proficiency" on the concepts of Central Dogma of Molecular Biology before conducting the study.

On the other hand, the mean and percentage of the posttest scores of the learners on the Central Dogma of Molecular Biology concepts were computed. Based on the percentage values, descriptions were offered. The posttest mean mastery level scores of the learners on the concepts of Central Dogma of Molecular Biology were presented in Table 4.

Table 4

Learners' Posttest Mean Mastery Level Scores on the Central Dogma of Molecular Biology Concepts

Concepts	No. of Items	Mean ± SD	Percentage	Description
A. DNA Replication	16	14.02 ± 1.44	87.63	Advanced
B. Transcription	8	6.35 ± 0.98	79.43	Proficient
C. Translation	16	13.06 ± 1.33	81.64	Advanced
Overall	**40**	**33.44 ± 2.94**	**83.59**	**Advanced**

Note. 0%-20% = Beginning 61%-80% = Proficient
21%-40% = Developing 81%-100% = Advanced
41%-60% = Approaching Proficiency

The posttest result showed that, out of 16 items on the concept of DNA Replication, the learners obtained a mean mastery level score of 14.02 ± 1.44 or 87.63%. This suggested that the learners were "advanced" in the concept of DNA Replication. On the other hand, out of 8 items on the concept of Transcription, the learners obtained a mean mastery level score of 6.35 ± 0.98 or 79.43%. This indicated that the learners were "proficient" in the concept of Transcription. Nevertheless, out of 16 items on the concept of Translation, the learners obtained a mean mastery level score of 13.06 ± 1.33 or 81.64%. This indicated that the learners were "advanced" on the concept of Translation. Meanwhile, it could also be deduced in Table 4 that, out of the total 40 items on the concepts of Central Dogma of Molecular Biology, the learners registered an overall mean mastery level score of 33.44 ± 2.94 or 83.59%. This revealed that the learners were "advanced" on the concepts of Central Dogma of Molecular Biology after conducting the study.

To determine if there was a difference between the mean mastery level scores of the learners on the Central Dogma of Molecular Biology concepts before the conduct of the study and the learners' mean mastery level scores after the simulation-based instructional materials were employed, a paired-samples t-test was utilized. Exploratory data analysis revealed that were no outliers in the distribution. The pretest and posttest scores distributions were normally distributed as assessed by the Shapiro- Wilk's test with p=0.313 and p=0.260, respectively. Table 5 demonstrated the paired-samples t-test of the pretest and posttest mean mastery level scores of the learners on the Central Dogma of Molecular Biology concepts.

Table 5

Paired-Samples T-Test of the Learners' Pretest and Posttest Mean Mastery Level Scores on the Central Dogma of Molecular Biology Concepts

Concepts	Pretest Mean ± SD	Posttest Mean ± SD	Mean Difference
A. DNA Replication	10.17 ± 2.46	14.02 ± 1.44	3.85*
B. Transcription	3.81 ± 1.00	6.35 ± 0.98	2.54*
C. Translation	9.04 ± 3.15	13.06 ± 1.33	4.02*
Overall	**23.02 ± 5.82**	**33.44 ± 2.94**	**10.42***

Note. *significant at 0.05 level of significance

The result of the paired-samples t-test revealed a statistically significant difference ($p<0.05$) between the pretest and posttest mean mastery level scores of the learners on the concepts of DNA Replication, Transcription, and Translation. Likewise, a statistically significant increase in the mastery level scores of 3.85, 2.54, and 4.02 on DNA Replication, Transcription, and Translation concepts was observed, respectively.

Furthermore, it could be observed in Table 5 that there was a statistically significant difference ($p<0.05$) between the overall pretest (23.02 ± 5.82) and posttest (33.43 ± 2.94) mean mastery level scores of the learners. Accordingly, a statistically significant increase in the overall mastery level scores of 10.42 on the concepts of Central Dogma of Molecular Biology was observed.

The low pretest mean mastery level score of the learners on the concepts of Central Dogma of Molecular Biology connotes less prior knowledge and misconceptions of the concepts as they need the prerequisite knowledge on cell division and reproduction to be able to explain the process of gene transmission correctly. This finding supported the argument of Change and Anderson (2020) and Picardal and Pano (2018) that there was a lack of basic knowledge on Genetics and Genetics technologies by the learners, and widespread misconceptions at various levels. Meanwhile, the significant increase in the posttest mean mastery level score of the learners signified the pronounced effect of the simulation-based instructional materials to the learners' learning on the concepts of Central Dogma of Molecular Biology. This indicated that learners had developed a conceptual understanding of DNA Replication, Transcription, and Translation mechanisms. Computer simulations were proven to develop learners' thinking and interpretation skills, thus, resulting in the development of higher-order thinking skills (Efe & Efe, 2011). The present study conformed to the different research findings that the use of computer simulations in teaching resulted in better learning outcomes for the learners (DeCaporale-Ryan et al., 2016; Gunda & Dongeni, 2017; Mceneaney, 2016; Olga, et al., 2020).

One of the reasons for the success of the learners in the posttest result was probably the fact that simulations help learners to visualize processes that seem abstract and complex such as the structure and composition of DNA, DNA replication, the use of knowledge in DNA to generate messenger RNA (mRNA), and the processing of functional proteins using the mRNA as a template.

According to Gunda and Dongeni (2017), utilizing visual instructional tools in teaching and learning environments is relevant and highly useful since it allows learners to envision and explore the implications of the model's rules for a method or system. This, in turn, can aid in the development of the learner's self-confidence and logical thinking skills (Mceneaney, 2016). There are some benefits of using models to teach the Central Dogma of Molecular Biology. They are both secure and practical to use. Furthermore, they often take less time to manipulate and can be replayed as many times as possible (Sahin, 2006). Decades of studies have also identified a correlation between constructive motivation and a good learning atmosphere using computer simulations (DeCaporale-Ryan et al., 2016; Flanagan, 2009; Gunda & Dongeni, 2017; Mceneaney, 2016; Olga et al., 2020; Reddy & Mint, 2017; Ulokok & Sari, 2016).

On the contrary, several studies have demonstrated that using computers and technology-based instructional materials in the teaching- learning process elicits some negative reactions. Greene (2001) mentioned that digital technology has the potential to reduce the interpersonal component of teaching since that the essence of teaching is the development of knowledge through relationships with learners in order to help them understand the concepts. The intertwining of emotional and intellectual bonds gives meaning to the teaching-learning process. Similarly, Bautista (2011) asserts that computers and the internet cannot imitate the art of teaching. These resources may enhance an already high- quality educational experience, but relying on them as the sole source of learning is a costly mistake.

Learners' Attitudes on Simulation-Based Instructional Materials

The participants' responses through semi-structured interviews were analyzed and synthesized into specific codes. Similar codes were grouped into categories and were consequently synthesized in an overarching theme. Based on the responses of the participants, one theme emerged. This theme collectively characterized learners' attitude exposed to simulation-based instructional materials: *Engaged in Experiential Learning* (Table 6).

Table 6

Learners' Attitudes on Simulation-Based Instructional Materials

Codes	Categories	Theme
Interactive Engaged in deeper understanding of lesson through experience Engaged in better understanding of concepts through interaction Engaged in better understanding and application of concepts through interaction	Engaged in Better Concept Attainment through Experience	Engaged in Experiential Learning
Helpful in understanding of concepts through visuals Engaged in better understanding of concepts through visuals Engaged in easy understanding of concepts through visuals	Engaged in Better Concept Attainment through Visuals	

Codes	Categories	Theme
Engaged in self –reflecting questions Engaged in evaluating one's action	Engaged in evaluative thinking	Engaged in Experiential Learning

Engaged in Experiential Learning

The result of the thematic content analysis on the responses of the learners revealed that they were engaged in experiential learning with the use of simulation-based instructional materials. Most of them pointed out that using the computer simulations made them more engaged with the better attainment of concepts through experience. They also emphasized that they better understood the concepts because they could experience the activity first-hand through engaging interactions. The following were some of the responses of the participants:

S5 shared:

"… mas lalalong maintindihan yung lesson. Tapos hindi lang yung parang nag iimagine ka lang pero parang na eexperience mo talaga. Although simulation lang siya parang na eexperience mo pa rin kung paano ba talaga naga work yung bagay bagay." [… the lesson was better understood. You do not just imagine, but it seems like you can really experience. Although it is just a simulation, it seems like you can still experience how things work.]

S4 also added:

"…you can interact, and you are the one who is manipulating, and there is a clear picture and view on how the processes are made. You can see it not just read it, and the process is very instructional sir. The way you interact with the simulations it can help you better understand the lesson."

From the gathered data, it can also be noted that learners were able to understand the concepts better using the simulation-based instructional materials because they could visualize the information, giving them a concrete experience of what is happening in the processes. Some of the responses of the participants were the following:

S6 emphasized:

"… kung i-compare ko siya sa usual na lessons, more on presentations lang na usual, hindi ko kaayo ma grasp ang mga ideas and hindi ko ma follow ang instructions properly. Whereas kung may simulation, makita ko siya properly at mas maintindihan kung ano ang nangyayari sa process mismo." […if I were to compare it to the usual lessons, more on the usual presentation, I cannot really grasp the ideas and I cannot follow the instructions properly. Whereas if there is simulation, I can see it properly and I can really better understand what is happening in the process.]

S5 shared:

"… makita po namin kung paano nagawork yung DNA. Hindi lang po imagination namin parang navivisualize rin po namin kung ano po talaga yung nangyayari sa loob. Mas na iintindihan po namin yung processes." [… we can see how the DNA works. We do not just imagine, but we can really visualize what is happening inside. We can really understand better the processes.]

Meanwhile, the learners also pointed out that the simulation-based instructional materials engaged them in evaluative thinking. They emphasized that they were able to evaluate the consequences of their actions with the computer simulations. The following were some of the responses:

S8 shared:

"… it can give me chance to evaluate the consequences of my actions and the importance of minimizing my errors, sir."

S4 also added:

"…we think of the process like we also question ourselves how did it get to this, like…we always asked questions how and why instead of just simply defining."

The results of the study presented collectively revealed that computer simulations engaged learners to understand the concepts through experiential learning better. This strengthened and supported the significant increase in the posttest mean mastery level score of the learners that the simulations based-instructional materials have pronounced effects on the learners' learning on the concepts of Central Dogma of Molecular Biology. According to Juan et al. (2017), experiential learning such as simulation is commonly used in teaching to engage learners in critical and evaluative thinking and self-directed learning (Pugh et al., 2020). It allows learners to apply things they have learned to real world experiences immediately. In the study conducted by Hakeem (2001), learners engaged in experiential learning have a greater understanding of their subject matter than learners in a traditional lecture class. Furthermore, DeCaporale-Ryan et al. (2016) posited that computer simulations could enhance learning by engaging learners to create dynamic systems models by combining words with pictures. This also conforms to the study of Gunda and Dongeni (2017) that computer simulations can engage learners to visualize and investigate the consequences of the rules of the model for a system and develop a conceptual understanding that can reveal learners' thoughts, ideas, and experiences (Isiaka & Mudasiru, 2016).

Similarly, the data collected revealed that learners were actively involved in the learning process through interacting in practical, dynamic, complex, and evaluative contexts. According to Abelsson (2017), active participation in learning entails evaluating what happens before and after an operation. When learners use an evaluative method focused on a hypothesis or personal interactions, they develop their analytical reasoning and more profound comprehension of concepts (Cant & Cooper, 2017). Furthermore, several authors emphasized the effectiveness of using computer simulations in creating scenario-based environments in which learners can interact and apply their knowledge and skills to solve real-world problems, improve their learning and thinking power, and evaluative thinking (Gunda & Dongeni, 2017; Mceneaney, 2016; Olga et al., 2020).

Conclusions and Recommendations

This study sought to determine the mean mastery level scores of the Grade 12 learners in Central Dogma of Molecular Biology concepts before and after the conduct of the study and their attitudes on the simulation-based instructional materials. Results of the study showed that the learners were proficient in the concept of DNA Replication and approaching proficiency in the concepts of Transcription and Translation before the conduct of the study. On the other hand, the learners were advanced in the concepts of DNA Replication and Translation and were proficient in the concept of Transcription after the conduct of the study. Furthermore, there was a significant difference ($p<0.05$) in the mean mastery level scores of the learners on the concepts of Central Dogma of Molecular Biology before and after the conduct of the study. The thematic content analysis revealed that the learners were engaged in experiential learning using simulation-based instructional materials. This strengthened and supported the significant increase in the posttest mean mastery level score of the learners that the simulations based-instructional materials have pronounced effects on the learners' learning on the concepts of Central Dogma of Molecular Biology.

However, this study was conducted on a small sample size of participants; hence, to conduct further study on a broader scope to improve the effectiveness and practicability of the simulation-based instructional materials are suggested. The simulation-based instructional materials used in the study were also limited and primarily based on the researchers' preferences; hence, it is suggested that other computer-aided simulation tools and educational software be used in teaching the Central Dogma of Molecular Biology concepts and that their effectiveness towards learners' learning performance be assessed, as well as any potential problems with their use to validate their usefulness further. While the current study may be limited to only a few participants, this research could serve as a baseline for succeeding simulation-based instructional materials studies in science education.

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Aggregating Attention, Emotion, and Cognition Load as Basis for Developing a Rule-based Pedagogy for Online Learner

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Abstract

The e-learning system offers an opportunity for educational strategists to monitor the learners' status and improve the teaching-learning outcomes. The study aims to analyze the electroencephalogram (EEG) signal of the learners' attention, emotion, and cognition as determining factors to recommend an appropriate learning pedagogy for every learner. The study analyzed 5,400 data signal datasets with the application of different algorithms to optimize and label the signal classification categories. The data signal components were aggregated as inputs to the regression model. Its resulting p-value determined the prioritization which significantly impacted the learners' learning process. Based on the initial simulation of signal analysis, the study recommends an individualized rule-based pedagogy for each learner, incorporating the EEG instrument to collect the affective and cognitive attributes that can help the learners to adjust better and follow their learning process with minimal supervision of the educational strategist. Likewise, implementing this study in the current e-learning system would provide tremendous learning benefits and improvements in the teaching-learning process.

Keywords: *e-learning, electroencephalogram signal, aggregated function, regression model, rule-based pedagogy*

Introduction

The unprecedented impacts brought about by the COVID-19 pandemic compelled educational institutions to transition to an online learning environment through various learning applications (Ali et al., 2020). Therefore, academic strategists were forced to develop well-designed courses that balance theoretical and practical teachings to cope with the new virtual setting (Kaur et al., 2020). Learners' engagement and motivation must be established more than ever to improve their learning process and embrace technological innovation as it will help them gain competitive advantage (Sun & Chen, 2016) and cultivate their cognitive, attention, and emotional capacities towards learning (El Kerdawy et al., 2020). In fact, the relationship between these components has been significantly supported in several studies, where attention and cognition were found to have a significant connection in ensuring learners' achievement (Braude & Dwarika, 2020; Ellah et al., 2019; Peng & Kievit, 2020). Moreover, Hasher's (2010) study showed a positive correlation between emotion and cognition in terms of e-learning success and suggested that emotion is a significant element in improving learners' attention spans and teaching-learning outcomes (Butt & Igbal, 2011; Huang et al., 2020; Qin et al., 2020).

As various studies delved into attention, emotion, and cognition to investigate the learning process, a study conducted by Huang et al. (2020) calculated the cognitive status based on attention, measuring the learner's ability and performance scores (Zhang et al., 2020). Eye-gaze was also used to determine the learners' attention (Costecu et al., 2019). Accordingly, Chisari et al. (2020) examined the said component through visual ability, whereas Yuan and Yang (2020) and Ciu et al., (2019) assessed attention based on user preferences. Further, Hlas et al. (2019) also studied other possible factors determining whether attention is based on working memory. Aside from attentiveness, emotion is also considered to be effective in the learning process, particularly in assessing student comprehension (Jia et al., 2021). In fact, it has been found that it also serves as a source of student motivation (Valverde-Berrosco et al., 2020), with the learners' body posture being closely linked (Revadakar et al., 2020). Likewise, facial expressions and electroencephalogram (EEG) signals are now being used to study the learners' emotions (Li et al., 2019). More studies were conducted to look into the field of emotion which also include a gender-based comparative analysis of emotions (Dores et al., 2020), emotional experiences encountered during e-learning sessions (Pal et al., 2020), and emotions assessed through using different types of images (Moroto et al., 2020). On the other hand, the cognition and cognitive abilities of the learners were found to be measured through test administration (Liu et al., 2015). Consequently, Paas and Merrienboer (2020) stated that assigning extremely difficult learning tasks distributes cognitive load among learners, and it could be best assessed through the task difficulty and performance scores (Hettiaracchi et al., 2018).

Based on the reviews conducted, most of the studies are descriptive in nature as some only focused on psychological aspects by assessing memory load, and there were only a few that utilized technologies to assess attention, emotion, and cognition among learners due to research limitations in adopting artificial intelligence (AI) to both pedagogical and psychological aspects (Zawacki et al., 2019). As Homes et al. (2019) asserted that academic integration of AI is limited, which then explains why only a minority of educators know the benefits of incorporating AI into the teaching-learning process (Linder, 2019). These factors greatly influenced this study's motivation to employ AI via an EEG tool, as only limited research had used the said technique (William et al., 2020). Several recommendations on using an EEG tool on assessing the cognitive load (Ahmad et al., 2020) and investigating changes on students' attention (Huang et al., 2020) were also suggested to understand the teaching-learning process better.

Grounded on integrating AI in the academic setup, this study would also like to investigate the issues and challenges in e-learning that concern the learner's attention, emotion, cognition load, and skills to see how they affect the e-learning system. The first component specifically tackles the learners' attention issues for it is noted that their attention in an e-learning environment is heavily distracted by complex learning content presentations, and learners cannot relate the importance of the stated information to the learning objectives. The visual display also affects their attention (Amadioha, 2019; Bradbury, 2016; Ghorbani et al., 2019; Tremolada et al., 2019;), and findings revealed that the best way to increase a learner's attention is to provide cognitive activities through problem-solving and thinking (Ellah et al., 2019). Alongside attention, the learners' emotions come as the second component. A study by Hewson (2018) mentioned that learners who engage in e-learning were mostly frustrated. Thus, one of the most prevalent emotions detected in e-learning is anxiety due to excessive boredom towards task irrelevancy, which was also found to be detrimental to student academic performance. Hence, positive emotions were detached in e-learning materials with less critical topics and irrelevant learning contents (Hasher, 2010). Another cited issue in e-learning is that learners get confused about the faulty learning materials, significantly affecting understanding and learning (Lodge et al., 2018). In terms of providing activities, studies revealed that learners also experience test anxiety in the e-learning set-up. Likewise, the activities in the new e-learning environment may pose positive emotions for learners to perform better (Adesolo & Yi, 2020).

On the contrary, negative emotions were observed when the given task was complex (Shao et al., 2019) leading to another challenge in areas of facilitating all the learning materials while receiving negative emotions in a short period (Li et al., 2020). Based on the reported cases in e-learning, the general emotions that the learners feel include enjoyment, hope, pride, relief, anger, anxiety, shame, hopelessness, and boredom. The third component is learner cognition, where several studies investigated if the quality of e-learning materials provides poor instructions that suggest lower performance levels (Costley, 2019). It has also been found that learning activities with multiple information sources reduce cognitive load (Winn et al., 2019), making the learners' intrinsic cognitive load and their ability to receive and process information be limited. In contrast to this, the learners' extraneous cognitive load understands the simulation lecture's information when they have a low mental load level (Permana et al., 2019). Furthermore, as stated in the systematic review of Hwang et al. (2021), most of the studies on AI in education from 1996 to 2019 measured the students' actual learning performances, and only few have considered the students' higher-order skills. However, despite being so invested in the students' skills, none of the studies delved into the students' cognitive load.

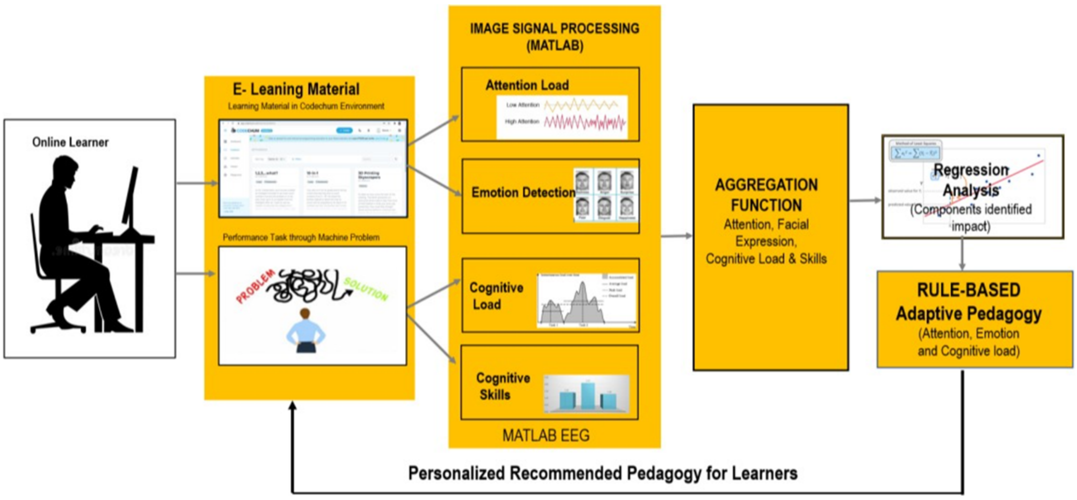
Therefore, this study looked closely at these critical components, including the valuable tools for assessing the students' learning process to arrive at an in-depth assessment of academic competence and valuable inputs for educational strategists. The results from this study would also allow the implementation of more appropriate learning pedagogies through improving the teaching-learning outcomes, which concerns the relevance and usefulness of learning content and the overall strategies being used in learning. Additionally, as this study considered using an EEG tool to conduct a more comprehensive diagnostic assessment of the learner's mental state, including their ability to absorb, process, and manage the received information, it would enable real-time assessments in the e-learning environment and permit generating relevant data that could be utilized as a strong basis for stakeholders' decision-making.

Objectives

The overarching objective of the study was to establish aggregated functions for attention, emotion, and cognition load as bases to develop a rule-based pedagogy approach for online learners.

Figure 1

Conceptual Framework of an Aggregated Function that serves as a Basis for Rule-Based Adaptive Pedagogy



Each learner performs two different tasks. The learners are instructed to wear the EEG tool while reading the e-learning material to capture and record both of their attention and emotion, which would then lead to performing the machine problem activities to capture and record the learner's cognitive load and skills. The data would be collected and extracted for further analysis through using algorithms and mathematical functions. The final data signal of the learner's attention, emotion, and cognition load values would be aggregated as input to the regression model. The created model would identify which among the three variables/components show the significant impact that could serve as a basis for selecting adaptive pedagogy to improve the existing e-learning system.

Review of Related Literatures

As presented in the introduction, the variables in this study are the identified critical components based on numerous existing studies that also delved into assessing the status of learners' learning process. Attention, emotion, and cognition emerged as the most effective and significant domains of the learners, based on the variety of approaches and methodologies used. In this study, these three (3) components were mainly employed to collect comprehensive data that educational strategists may consider, to improve the teaching-learning process.

Attention

A learner's attention is a factor in attaining academic achievement and personal and social development (Braude & Dwarika, 2020). Several characteristics that define and affect attention include having the individual capacity for information processing, attentiveness, inattention, divided attention, flexibility, and sustained attention (Tremolada et al., 2019). It varies according to individual preferences and circumstances, which were also proved by additional studies that examined attention on a cognitive level (e.g., Huang et al., 2020). As Costescu et al. (2020) investigated eye-gaze in measuring attention, some studies assessed attention through performance scores (Zhang et al., 2019), and learning working memory (Hlas et al., 2019; Yuan & Yang, 2020). Observing learners' attention value to various learning materials (Huang et al., 2020) and assessing attention in terms of individual differences in information processing (Liu et al., 2019) were indicated as useful inputs for further investigation. Furthermore, Zhang et al. (2020) emphasized that it is likewise necessary to measure attention in terms of performance tasks.

Emotion

Facial expression is a highly effective method in deciphering social interactions. Emotions are used to demonstrate student motivation (Valverde-Berrocoso et al., 2020) as it broadens the perspective of the learners (Shao et al., 2019). Numerous studies, such as Moroto et al. (2020), have also examined the emotional component considering the emotions through visual responses to images. Body posture was also found effective in assessing learners' emotions during e-learning lessons (Revadekar et al., 2020). Hence, Li et al. (2019) and El Kerdawy et al. (2020) studied the fusion of EEG and facial expressions to understand the learning process better. Despite having intensive studies on gender-specific emotions (Dores et al., 2020), and assessing emotions during e-learning sessions through Learning Management Systems (LMS) data (Pat et al., 2020), the emotion component has been discovered to have no effect on either attention or cognitive abilities (Deng & Ren, 2020; El Kerdawy et al., 2020).

Cognition

A recent study conducted by Peng and Kievit (2020), established that the students' cognitive abilities directly affect their academic success. Similarly, innovative instructional strategies promote critical and analytical thinking (Chisari et al., 2020) as cognitive exercises (Ratniece, 2019) promote higher-order thinking and problem-solving abilities. It also demonstrates (Tachie, 2019) practical and physical abilities. Songkram et al. (2014) even emphasized that cognition is heavily based on the learner's scientific thinking process and systematic abilities.

Alongside investigating the learners' cognitive abilities, studies on assessing it were also conducted, where test assessments (Liu, 2015) and learners' performance were found to be relevant (Hettiarchchi et al., 2018). Numerical ability, logical reasoning ability, and perceptual speed (Kalpanedi, 2019) were also considered to be significant. Consequently, a study by Joe-Hee et al. (2019) established a relationship between various workloads where the learners' cognitive load may be assessed (Ahmad et al., 2020; Farisha et al., 2019). To better understand the learners' cognitive potentials, studies recommend more inputs to investigate cognitive capacities based on brain signals (Ahmad et al., 2020) and consider additional samples with extraneous variables (Ahmad et al., 2020; Joo-Hee et al., 2018).

Methodology

Research Design

The study used a quantitative approach and an experimental design to ascertain the relationship between the variables examined, specifically implying attention, emotion, and cognition as independent variables based on EEG signal. The performance scores from the machine problems serve as the dependent variable. The regression result will serve as input to recommend appropriate teaching pedagogy to improve e-learning.

Respondents

Learner Respondents

The study applied the proportionate stratified random sampling technique that follows the formula: nh = (Nh / N) * n, where the selected respondents have a brief background in C++ programming as a pre-requisite of the study. The respondents were composed of ten (10) males and ten (10) females.

Validator Respondents

The study used a purposive sampling technique in selecting the respondents to perform ranking on their priority pedagogy, based on the learner's level of attention, emotion, and cognition. The criteria among respondents included having a Master's or Doctoral degree in education and at least five years of teaching experience.

Data Gathering Procedure

The researchers intended to develop an e-learning material covering the iterative structures and arrays using C++ programming language, including learning objectives, salient information, simulation, sample code, flowchart, pseudocode, and machine problems. Before facilitating the material, experts evaluated the learning material and the machine problem to ensure its alignment and relevance to the identified learning objectives.

Before the Actual Conduct of the Experiment

Each learner took a pre-test on C++ Computer Programming, consisting of thirty (30) multiple-choice questions ranging from easy, average, and difficult to check on the learner's logical thinking abilities without using an EEG. The activity's concept and content were set to be similar, but the machine problems, on the other hand, were constructed differently in a way that it could investigate the learners' performance consistency. The post-test would then involve learners' wearing the EEG tool while completing the machine problem. Hence, the learners' pre-test and post-test results were compared.

During the Actual Conduct of the Experiment

The subjects were placed in a controlled environment to avoid disruption from environmental factors. The Emotiv EPOC+14 Channel Mobile Encephalogram (EEG) tool recorded the learners' attention, cognition, and emotion every 20 seconds. The subjects performed the eyes-closed and eyes-opened practice to establish the learner's relaxation mode before collecting the data on their memory working before reading and performing the tasks. As a result, the study collected a total of 5,400 datasets.

Table 1

Total number of Datasets

Subject	No of Subjects	Attention	Emotion	Cognition	Total datasets
Female	10	90	90	90	2,700
Male	10	90	90	90	2,700
				Over-all total	5,400

Analysis

As shown in Figure 2, the data collected were extracted and processed using algorithms. Each recorded signal for every learner was aggregated using a weighted mean to arrive at the final value of the learner's attention load (AI), emotion load (EL), and cognitive load (CL) (see Equations 1, 2, 3). These three (3) variables served as the independent variables, and the performance scores served as the dependent variable. The p-value result of the regression was then used to determine the rule-based approach that affected the pedagogical strategy of the learner. Hence, the generated results from this study could be used as a valuable tool for the educational strategists to arrive at the best-recommended pedagogy. This will also provide information to educational strategists to improve the learning materials as the attention and emotion of the learners are investigated and possibly redesign or revisit the machine problem given to the learners as the cognitive load is investigated.

Figure 2

EEG Signal Extraction and Processing

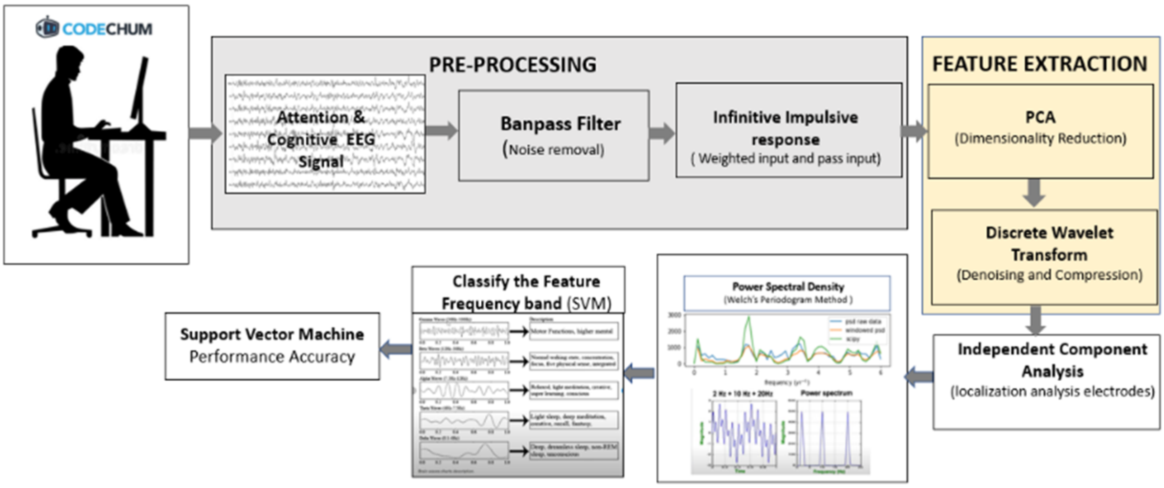


Figure 2 shows the method of processing the signals extracted from the BCI Software. The study utilized the MATLAB EEG tool to process the signals and arrive at the final value of the EEG signal through implementing algorithms such as Bandpass filter and infinite impulse response (IIR) filter to remove the noise. The Principal Component Analysis (PCA) was also used for signal feature extraction and dimension reduction. The discrete wavelet transforms also assisted in looking into the frequency signal. Moreover, the Independent Component Analysis (ICA) with a runica method to isolate the signal source was utilized. The autocorrelation function estimated the Fourier transform signal's power spectrum, and Welch's Periodogram method computed the Fourier transforms to better determine the brain signal's oscillatory mode levels.

Table 2

Oscillation Mode

Type of Waves	Frequency	Classification
Gamma Waves	32Hz-63Hz	Higher Mental Load
Beta Waves	16Hz-32Hz	Normal Mental Load
Alpha Waves	8Hz-12Hz	Low Mental Load

Aggregated Function

The data collected were extracted and processed using algorithms. Each recorded signal for every learner was aggregated as shown in the function, by using a weighted mean to arrive at the final value of the learner's attention, emotion, and cognitive load where it combined three variables as expressed:

$$AI/CL/E = \sum_{i=0}^{n} \frac{s1 + s2 + s3 + s4 \ldots}{n}$$

Where: AI = Attention load; CL = cognitive load
E= emotions; s = brain signal frequency data
n = number of collected brain signal frequency data

For the emotion data, the recorded data were labeled based on the six basic emotions: happy, sad, neutral, disgust, anger, and surprise, which were computed (see Equation 1).

$$te = \left(\frac{secm}{sec}\right) x\ tnms$$

Where: secm = equivalent of sec; sec = actual equivalent of sec; tnms = total number of minutes; te = total number of emotions

To establish the emotion combination pattern, the study applied percentage distributions to determine the emotion category (see Equation 2).

$$pve = re\ x\ te$$

Where: pve = percentage value per Emotion; re = specific recorded Emotion; te = total number of emotions

The recorded higher frequency values served as inputs to the combinatorial analysis adopted in the study of Mukhopadhyay et al. (2020), which was reflected (see Equation 3).

$$c = (n + s + sd)$$

Where: c = confusion; n = neutral; sr = surprise; sd = sad

$$s = (h + n)$$

Where: s = satisfaction; h = happy; n = neutral

$$d = (n + sd)$$

Where: d = dissatisfaction; n = neutral; sd = sad

$$f = (s + an + n)$$

Where: f = frustrated; s = sad; an = angry; n = neutral

Regression Model

The aggregated attention, emotion, and cognitive load values were the independent variables, with the learners' performance score as the dependent variable. The regression results provided empirical outcomes based on the obtained p-values with a 0.05 level of confidence. This p-value served as a basis to determine the variables' significance (see Equation 4).

$$\hat{Y} = b_0 + b_1 Al_1 + b_2 Fe_2 + b_3 Cl_3 + \cdots \mathbf{b_p} X_p$$

Where:

y = predicted or expected value of the dependent variable (performance score)

b_0 = value of Y when all independent variables are equal to zero

$Al_1Fe_2Cl_3$ = independent variables or predictors that consist of attention, emotion, and cognitive load

b_1 = through b_p are the estimated regression coefficients

Rule-Based Pedagogy

The study established a survey of the three significant components: attention, emotion, and cognition to determine the recommended pedagogy. The experts in the education field ranked these components according to the mental load types such as high, normal, and low load using a scale of 1 to 5 using the design rule-based below.

Ethical Considerations

Prior to the simulation, the researchers obtained consent to process, share, and protect all relevant information that was solely collected for research purposes only. In accordance with the Data Privacy Act, the purpose of the study was also clearly articulated among the respondents. Foremost, the study ensured that proper safeguards were in place while conducting experiments and recording the brain signals of the respondents.

Results and Discussions

This study presented the simulated analysis result based on the data signal classification category, classified as High Mental Load, Normal Mental Load, and Low Mental Load. Below is the expert judgment of mapping the prioritization of the best relevant pedagogy for specific online learners.

Table 3

Mapping of Recommended Pedagogy based on Cognitive Load

LOAD TYPE	RECOMMENDED PEDAGOGY BASED ON COGNITIVE LOAD CLASSSIFICATION				
High Mental Load	5th Priority	4th Priority	3rd Priority	2nd Priority	1st Priority
	HL>=33 && HL<=38 Hz	HL>=39 && HL<=44	HL>= 45 && HL<=50	HL>=51&& HL<=56	HL>=57 && HL <=63
	Reflective	Collaborative	Constructivist	Inquiry	Integrative
Normal Mental Load	5th Priority	4th Priority	3rd Priority	2nd Priority	1st Priority
	NL>=16 && N M<=18 Hz	NL>=19&& NL<=21	NL>=22&& NL<=24	NL>=25&& NL<=27	NL>=28 && NL <=32
	Collaborative	Integrative	Reflective	Constructivist	Inquiry
Low Mental Lod	1st Priority	2nd Priority	3rd Priority	4th Priority	5th Priority
	LL>=1 && LL<=2 Hz	LL>=2&& LL<=5	LL>=6&& LL<=8	LL>=9&& LL<=10	LL>=11&& LL<=15
	Integrative	Reflective	Collaborative	Inquiry	Constructivist

Table 3 depicts the recommended pedagogy based on the cognitive load of the learners. The categorization is based on signal oscillation classification through the scaling method to set up the range per priority.

Criteria No.1: High Cognitive Load

IF Cognitive Load >=57 && <=63 THEN recommend 1st Priority Pedagogy
ELSEIF Cognitive Load >=51 && <=56 THEN recommend 2nd Priority Pedagogy
ELSEIF Cognitive Load >=45 && <=50 THEN recommend 3rd Priority Pedagogy
ELSEIF Cognitive Load >=39 && <=44 THEN recommend 4th Priority Pedagogy
ELSE Cognitive Load >=33 && <=38 THEN recommend 5th Priority Pedagogy

Criteria No.2: Normal Cognitive Load

IF Cognitive Load >=28 && <=32 THEN recommend 1st Priority Pedagogy
ELSEIF Cognitive Load >=25 && <=27 THEN recommend 2nd Priority Pedagogy
ELSEIF Cognitive Load >=22 && <=24 THEN recommend 3rd Priority Pedagogy
ELSEIF Cognitive Load >=19 && <=21 THEN recommend 4th Priority Pedagogy
ELSE Cognitive Load >=16 && <=18 THEN recommend 5th Priority Pedagogy

Criteria No.3: Low Cognitive Load

IF Cognitive Load >=1 && <=2THEN recommend 1st Priority Pedagogy
ELSEIF Cognitive Load >=2 && <=5 THEN recommend 2nd
Priority Pedagogy
ELSEIF Cognitive Load >=6 && <=8 THEN recommend 3rd Priority Pedagogy
ELSEIF Cognitive Load >=9 && <=10 THEN recommend 4th Priority Pedagogy
ELSE Cognitive Load >=11 && <=15 THEN recommend 5th Priority Pedagogy

Table 4

Mapping of Recommended Pedagogy based on Attention Load

LOAD TYPE	RECOMMENDED PEDAGOGY BASED ON ATTENTION LOAD CLASSSIFICATION				
High Attention Load	5th Priority	4th Priority	3rd Priority	2nd Priority	1st Priority
	HL>=33 && HL<=38 Hz	HL>=39 && HL<=44	HL>= 45 && HL<=50	HL>=51&& HL<=56	HL>=57 && HL <=63
	Collaborative	Integrative	Reflective	Constructivist	Inquiry
Normal Attention Load	5th Priority	4th Priority	3rd Priority	2nd Priority	1st Priority
	NL>=16 && N M<=18 Hz	NL>=19&& NL<=21	NL>=22&& NL<=24	NL>=25&& NL<=27	NL>=28 && NL <=32
	Collaborative	Integrative	Reflective	Integrative	Inquiry
Low Attention Load	1st Priority	2nd Priority	3rd Priority	4th Priority	5th Priority
	LL>=1 && LL<=2 Hz	LL>=2&& LL<=5	LL>=6&& LL<=8	LL>=9&& LL<=10	LL>=11&& LL<=15
	Integrative	Reflective	Collaborative	Inquiry	Constructivist

The mapping of recommended pedagogies dependent on the level of learners' attention load is shown in Table 4. The categorization is based on the signal's oscillation classification, with the range per priority set up using the scaling method:

Criteria No.1: High Attention Load

IF Attention Load >=57 && <=63 THEN recommend 1st Priority Pedagogy
ELSEIF Attention Load >=51 && <=56 THEN recommend 2nd Priority Pedagogy
ELSEIF Attention Load >=45 && <=50 THEN recommend 3rd Priority Pedagogy
ELSEIF Attention Load >=39 && <=44 THEN recommend 4th Priority Pedagogy
ELSE Attention Load >=33 && <=38 THEN recommend 5th Priority Pedagogy

Criteria No.2: Normal Attention Load

IF Attention Load >=28 && <=32 THEN recommend 1st Priority Pedagogy
ELSEIF Attention Load >=25 && <=27 THEN recommend 2nd Priority Pedagogy
ELSEIF Attention Load >=22 && <=24 THEN recommend 3rd Priority Pedagogy
ELSEIF Attention Load >=19 && <=21 THEN recommend 4th Priority Pedagogy
ELSE Attention Load >=16 && <=18 THEN recommend 5th Priority Pedagogy

Criteria No.3: Low Attention Load

IF Attention Load >=1 && <=2THEN recommend 1st Priority Pedagogy
ELSEIF Attention Load >=2 && <=5 THEN recommend 2nd Priority Pedagogy
ELSEIF Attention Load >=6 && <=8 THEN recommend 3rd Priority Pedagogy
ELSEIF Attention Load >=9 && <=10 THEN recommend 4th Priority Pedagogy
ELSE Attention Load >=11 && <=15 THEN recommend 5th Priority Pedagogy

Table 5

Mapping of Recommended Pedagogy based on Emotion

EMOTION	RECOMMENDED PEDAGOGY BASED ON EMOTION CLASSSIFICATION				
Satisfaction	5th Priority	4th Priority	3rd Priority	2nd Priority	1st Priority
	HL>=33 && HL<=38 Hz	HL>=39 && HL<=44	HL>= 45 && HL<=50	HL>=51&& HL<=56	HL>=57 && HL <=63
	Collaborative	Reflective	Constructivist	Inquiry	Integrative
Confusion	5th Priority	4th Priority	3rd Priority	2nd Priority	1st Priority
	NL>=16 && NM<=18 Hz	NL>=19&& NL<=21	NL>=22&& NL<=24	NL>=25&& NL<=27	NL>=28 && NL <=32
	Constructivist	Inquiry	Reflective	Integrative	Collaborative
Dissatisfaction	1st Priority	2nd Priority	3rd Priority	4th Priority	5th Priority
	LL>=1 && LL<=2 Hz	LL>=2&& LL<=5	LL>=6&& LL<=8	LL>=9&& LL<=10	LL>=11&& LL<=15
	Collaborative	Integrative	Reflective	Inquiry	Constructivist
Frustration	1st Priority	2nd Priority	3rd Priority	4th Priority	5th Priority
	LL>=1 && LL<=2 Hz	LL>=2&& LL<=5	LL>=6&& LL<=8	LL>=9&& LL<=10	LL>=11&& LL<=15
	Collaborative	Integrative	Reflective	Inquiry	Constructivist

The mapping of recommended pedagogies based on the level of learners' emotion load signal is shown in Table 5. Negative Emotions (Frustration and Dissatisfaction), Normal Emotions (Confusion), and Positive Emotions (Excitement and Joy) were the three types of emotions that correlate to (Satisfaction). According to Fredrickson (2011), low emotion denotes disengagement, while high emotion denotes engagement or satisfaction. The suggested rule- based approaches are as follows:

Criteria No.1: Positive Emotion (Satisfaction)

IF Positive Emotion >=57 && <=63 THEN recommend 1st Priority Pedagogy
ELSEIF Positive Emotion >=51 && <=56 THEN recommend 2nd Priority Pedagogy
ELSEIF Positive Emotion >=45 && <=50 THEN recommend 3rd Priority Pedagogy
ELSEIF Positive Emotion >=39 && <=44 THEN recommend 4th Priority Pedagogy
ELSE Negative Emotion >=33 && <=38 THEN recommend 5th Priority Pedagogy

Criteria No.2: Neutral Emotion (Confusion)

IF Neutral Emotion >=28 && <=32 THEN recommend 1st Priority Pedagogy
ELSEIF Neutral Emotion >=25 && <=27 THEN recommend 2nd Priority Pedagogy
ELSEIF Neutral Emotion >=22 && <=24 THEN recommend 3rd Priority Pedagogy
ELSEIF Neutral Emotion >=19 && <=21 THEN recommend 4th Priority Pedagogy
ELSE Neutral Emotion >=16 && <=18 THEN recommend 5th Priority Pedagogy

Criteria No.3: Negative Emotion (Frustration & Dissatisfaction)

IF Negative Emotion >=1 && <=2THEN recommend 1st Priority Pedagogy
ELSEIF Negative Emotion >=2 && <=5 THEN recommend 2nd Priority Pedagogy
ELSEIF Negative Emotion >=6 && <=8 THEN recommend 3rd Priority Pedagogy
ELSEIF Negative Emotion >=9 && <=10 THEN recommend 4th Priority Pedagogy
ELSE Negative Emotion >=11 && <=15 THEN recommend 5th Priority Pedagogy

Conclusions and Recommendations

It is critical to monitor the learner's mental state throughout the learning process as it reveals how they process, analyze, and manage the vast amount of information that they are exposed to in every class they attend daily. The simulation performed in this study established the greater importance of delving deeper and implementing a higher degree of diagnostic assessment based on the learners' affective and cognitive domains as these directly affect the learners' academic performance. The combined values of a learner's attention, emotions, and cognition have significantly served as valuable inputs to determine which component has the most substantial influence on the learner's learning process. Correspondingly, the designed rule-based pedagogy in this study has provided essential insights that can be used as a guide in selecting the best-suited learning pedagogy for every student. The approaches implemented in this study also opened up new opportunities for AI integration into the current e-learning and academic environment. It can fundamentally help make the system more efficient and effective to assess the learners' progress and enhance the teaching-learning outcomes. To further improve this study, it is recommended to engage more experts to re-validate the prioritization of the proposed rule-based design and to employ an in-depth mathematical analysis to improve the usefulness of the aggregation functions.

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Association Between Nursing Students' Self-Regulation and Online Learning Self-Efficacy

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Abstract

The COVID-19 pandemic has caused the suspension of face-to-face classes worldwide, which resulted in a shift to online learning. This presented a new challenge to students to improve their ability to complete tasks successfully and to direct their focus on acquiring knowledge and skills actively. Self-regulation (SR) and online learning self-efficacy (OLSE) are two important factors in online learning environments. SR allows learners to actively initiate and direct themselves, while OLSE refers to one's beliefs and confidence in their abilities to complete or engage in a specific task required of online learners. Several studies conducted in Asia revealed that college students have low to moderate SR. Meanwhile, there is little known information about self-efficacy (SE) in an online learning environment. Similarly, limited literature supports the results; however, other studies suggest a positive and significant relationship between SR and SE for learning. The objectives of the study were to determine and describe the association between nursing students' SR and OLSE Snowball sampling through social networking sites within Pampanga resulted in a sample of 166 nursing students. The results revealed that nursing students have moderate levels of SR ($x = 54.75$; $SD = 10.60$) and OLSE ($x = 93.01$; $SD = 25.03$). Pearson correlation coefficient revealed a statistically significant and strong positive association between nursing students' SR and OLSE ($r = .60$; $p = < .00$). Thus, the academic administration and nurse educators should explore the dynamics between the two variables and develop programs that may improve SR and OLSE.

Keywords: *online learning, self-efficacy, self-regulation, nursing students, undergraduate nursing, online survey*

Introduction

The COVID-19 pandemic has taken a massive toll on education systems around the world, affecting nearly 1.6 billion students in over 190 countries across the globe (United Nations, 2020). Although children are more protected from COVID-19, they could be sources of spread due to strong social contacts, such as those seen in schools (Abdulamir & Hafidh, 2020; Adler, 2020; Germann et al., 2019). Many countries are faced with the suspension of face-to-face classes and the shift towards an online learning environment. The Coronavirus Disease 2019, also known as COVID-19, first appeared in December 2019 and quickly gained the attention of scientists around the world. The first outbreak caused an epidemic with the sudden increase of cases, following into a pandemic when the spread was across several countries and affected many people (Centers for Disease Control and Prevention, 2020). Various countries implemented lockdowns to control and minimize the transmission of the virus. Needless to say, such pandemic-related restrictions affected the learning process.

In an online learning environment, students, to be successful, must act independently and control their learning without the physical presence of an instructor to facilitate learning. Self-regulation (SR) is one of the predictors of student performance, especially in an online learning environment (Delen & Liew, 2016). Self-regulated learners actively initiate and direct themselves to acquire knowledge and skill rather than relying on others, such as professors, parents, or peers (Delen & Liew, 2018; Fadda, 2019). In the absence of face-to-face classes and synchronous meetings, students must monitor their actions and change their behaviors accordingly to learn. A student's self-efficacy (SE) is another factor that affects their performance. SE is an individual's perception of their ability to complete a task successfully (Bandura, 1997). Students who lack confidence in their ability to succeed in a course are predicted to exert less effort than those who believe they can succeed (Zimmerman, 2017).

The findings of the study will benefit the students considering that online learning self-efficacy (OLSE) and SR play an important role in enhancing students' performance in an online learning environment. Without the physical presence of instructors to facilitate learning and peers to influence activity, students must be able to initiate and direct their own learning. Thus, the study will significantly develop and improve students' independence in an online learning environment.

The literature has addressed different perspectives regarding SR and OLSE; however, few studies have investigated these concepts in nursing undergraduates, especially about the association of SR and OLSE. Hence, the objective of this study is to determine if there is an association between nursing students' SR and OLSE. The results of the study will be helpful for future researchers, nursing administrators and academic leaders, and the participants themselves in finding interventions to improve both SR and OLSE. Nursing academic leaders may use the results to enhance their curriculum and lessons to empower SR and OLSE among nursing students. Furthermore, the results can help students recognize opportunities to set goals and guidance in SR and OLSE.

Objectives

This project aimed to achieve the following:

1. Determine if there is an association between nursing students' SR and OLSE; and
2. Describe the association between nursing students' SR and OLSE.

Review of Related Literature

COVID-19

In December 2019, a group of patients was hospitalized with an initial diagnosis of pneumonia caused by a new strain of coronavirus (Naja & Hamadeh, 2020). The virus was named by World Health Organization (WHO) as 2019 Novel Coronavirus on January 12, 2020 and became COVID-19 on February 11, 2020 (Guo et al., 2020; Rothan & Byrareddy, 2020; Shereen et al., 2020; Velavan & Meyer, 2020; World Health Organization, 2020a). Coronaviruses are enveloped non-segmented positive-send RNA viruses, with sizes ranging "from 26 to 32kbs in length" (Guo et al., 2020; Shereen et al., 2020, p 2; Velavan & Meyer, 2020). On March 11, 2020, WHO (2020a) declared the COVID-19 outbreak a global pandemic as the novel coronavirus rapidly spread worldwide. Measures such as quarantine and isolation were implemented globally as an attempt to control the spread of COVID-19 (Atalan, 2020; Kaplan, 2020; López-Carral et al., 2020; Rothan & Byrareddy, 2020). Social distancing, staying-at-home rules, work-related travel restrictions, and mass gatherings prohibitions were also enforced (López-Carral et al., 2020).

Although children are found to be more protected from COVID-19, they can become the sources of spread due to intense social contacts among others in schools (Abdulamir & Hafidh, 2020;

Adler, 2020; Germann et al., 2019). COVID-19 transmission may likely be high within the school setting due to large groups gathering indoors for extended periods of time (Lewis, 2020). Thus, education has been affected, and the opening of schools has been delayed (Palatino, 2020). Because of the impact of COVID-19, governments began implementing measures to limit the spread of the coronavirus in March 2020, including school closures (Li & Lalani, 2020; UNICEF, 2021). The Coordinating Council of Private Educational Associations (COCOPEA) conducted a survey in which out of 500 schools that responded, there are 400 private schools at risk of closing by the end of August due to lack of resources to maintain operations (Bernardo, 2020). On the contrary, public and private higher education institutions (HEIs) can still regulate classes with the "new normal" setting in education since face-to-face interaction is prohibited. Under those circumstances, education officials suggested using online platforms for the school year 2020-2021 to continue the schooling of millions of students (Hedger, 2020; Hunt & Oyarzun, 2019; Kritz, 2020; Simbulan, 2020).

Online Learning

Online learning is a form of education that utilizes technological devices, tools, and the internet. Multiple challenges come along with the shift towards online learning. The most frequent challenges that students face in online learning are difficulty in adjusting learning styles, poor communication such as lack of clear directions from instructors, poor internet connection, and challenges in performing responsibilities at home while in online classes (Adedoyin & Soykan, 2020; Baticulon et al., 2020). Students' self-confidence in using the Internet may also affect their academic performance considering that online classes require them to accomplish their assigned activities and internet-related tasks autonomously (Chang et al., 2014; Compeau & Higgins, 1995).

Self-Efficacy

In an online environment, students must embrace change, efficiently aim for what they want to accomplish, and do what is achievable. Most people may acknowledge that performing these tasks is not easy. As a major component of Social Cognitive Theory, an individual's SE goes into how goals, tasks, and challenges are approached and how it centers on human functioning (Bandura, 1997; Grether et al., 2018). In line with this, SE is a person's confidence in accomplishing and succeeding in a particular task. SE beliefs are associated with how people think, behave, and feel (Bandura, 1997). SE plays a role in how one perceives themselves and whether one successfully achieves goals in life. According to Bandura, mastery experiences, vicarious experiences, social persuasion, and physiological and emotional states are the components of SE associated with people's beliefs in their ability to produce desired results. Mastery experiences refer to prior experiences a person has for a particular task. Bandura also added that developing a sense of efficacy through mastery is a matter of learning a skill or improving performance by practice. Vicarious experience, on the other hand, is having a role model to match that person's achievement, typically by imitation; when people seek positive role models who display an ideal level of SE, the role models are likely to transmit knowledge and teach observers skills and strategies that can be utilized in life.

According to Bandura (1997), in social persuasion, words strengthen people's belief that they have the necessary qualities for success; people verbally persuaded to do specific tasks are likely to be encouraged and motivated to succeed. The achieved success is measured by self-improvement rather than by triumph over others. Bandura also added that physiological and emotional states as the fourth source of SE, where individuals correlate their physiological and emotional conditions with their capabilities, so SE is either strengthened or lessened depending on the individual's mood.

Domain-specific SE is one of the three forms of SE (Grether et al., 2018). Domain-specific SE beliefs signify confidence in an individual's coping ability within a particular environment, such as home or work (Grether et al., 2018, p.132). An example is SE that involves academics—the belief of an individual in their competence to perform tasks (Schunk, 1991; Linnenbrink & Pintrich, 2002; as cited in Yeşilyurt et al., 2016). The beliefs of individuals regarding their academic SE affect their learning and how they will likely increase their success.

According to several studies, nursing students are more vulnerable to stressors and psychological disturbances than students in other programs because nursing education is a highly competitive environment that most likely will impair their academic and social performance (American Association of College of Nursing, 2017; Levett- Jones et al., 2007; Ulrich & Lathlean, 2007; Versaeval, 2014, as cited in Raymond & Sheppard, 2017; Shehadeh et al., 2020). In an environment with such high demands, nursing students must apply concepts such as SE to help them face tasks and challenges in their learning endeavors. Considering SE is related to the concept of self-control and the ability to regulate behaviors to accomplish goals; in a descriptive-correlational study, the academic achievements of students are affected because of SE and that of "environmental factors, family and peer support, as well as educational, personal, cognitive and social factors" (Farokhzadian et al., 2018, p. 7). Internal and external factors—academic responsibility, lack of financial means, social concerns, health-related concerns, university environment may contribute to psychological disturbances among university students that may consequently influence student academic satisfaction corresponding with their academic performance (Shehadeh et al., 2020).

Online Learning Self-Efficacy

In online learning environments, SE is a critical psychological component that directly impacts students' performance and satisfaction. (Yavuzalp & Bahcivan, 2020). OLSE is a domain-specific SE defined as one's beliefs and confidence in their abilities to complete or engage in a specific task required of online learners (Zhu, 2019; Zimmerman & Kulikowich, 2016). Many researchers of OLSE consider only the technological aspect of online learning, when in fact OLSE is a multidimensional construct that consists of five factors (Shen, 2013; Zimmerman, 2017). Students with high computer and internet SE experience greater satisfaction and commitment to their studies, allowing them to engage effectively during activities (D'Errico et al., 2018; Kirmizi, 2015; Lee, 2015). On the other hand, students with limited or inadequate computer skills may have lower SE to handle tools in a course management system and tend to be less motivated to learn and participate in activities, which results in a lessened likelihood of success (D'Errico et al., 2018; Kirmizi, 2015; Eastin & LaRose, 2000, as cited in Lee, 2015). Another factor of OLSE is one's SE to complete an online course (Zimmerman & Kulikowich, 2016). Furthermore, an area that must be considered in terms of OLSE is social interaction, which covers the last three factors, SE to interact socially with classmates, SE to interact with instructors in an online course, and SE to interact with classmates for academic purposes (Shen, 2013, p. 12). Successful online learners must possess self-directedness, the ability to use technology, communication skills, and time-management skills (Zimmerman & Kulikowich, 2016). Students with high OLSE are more likely to persist longer and exert more effort in their learnings and tasks, whereas students with lower levels of OLSE may be less likely to engage in their activities due to the lack of confidence (Zhu, 2019; Zimmerman, 2017). Multiple studies have been conducted on college students' OLSE, but very few exist within the context of nursing education. With online learning normalized and implemented, understanding a student's motivation and perceived OLSE is necessary to yield positive outcomes and experiences.

Self-Regulation

Without the physical presence of instructors, learners must manage their schedule and engage with their materials independently (Sansone et al., 2011, as cited by List & Nadasen, 2016). SR is key in supporting learner autonomy and is an essential factor in predicting student performance (Pintrich, 1995 & Azevado, 2005, as cited in Chen & Su, 2019; Delen & Liew, 2016; Lee, 2015; List & Nadasen, 2016). SR is conceived to be a dynamic motivational system related to goal setting and goal attaining strategies (Jakesova et al., 2016). It is the skill of controlling and regulating cognition, behaviors, actions, motivations, and impulsivity autonomously in academic skills and goal attaining (Jakesova et al., 2016; Zimmerman, 1986 & Pandero, 2017 as cited in Lai et al., 2018; Türkben, 2019). Self-regulated learners can facilitate their learning by monitoring their progress and modifying their behaviors accordingly (Delen & Liew, 2016; Fadda, 2019; Lin et al., 2016). The SR process consists of three phases: forethought phase, performance phase, and self-reflection phase. The forethought phase includes task analysis and self-motivation beliefs (Metsärinne, 2014; Türkben, 2019). Task analysis involves goal setting and strategic planning, which are greatly influenced by one's self-motivation beliefs. These beliefs include SE, outcome expectations, intrinsic value, and goal orientation (Türkben, 2019). To further "elevate goal setting, the activities and materials provided should not conflict with the learners' interests and preferences" (Bursali, 2018, p. 668). The second phase of SR, the performance phase, "includes self-control and self-observation. Lastly, the self-reflection phase contains self-judgment and self-reaction" (Metsärinne, 2014, p. 88). Self-judgement is concerned with an individual's evaluation of their performance and characteristics, while self-reaction is more concerned with internal evaluation and causal attribution and consists of self-satisfaction and adaptive and defensive processes (Türkben, 2019). Students must be aware of their cognitive function in learning, known as metacognition, as it facilitates successful learning (Bursali, 2018, p. 662). Students must be allowed to set goals and be guided in elevating their metacognitive awareness to become autonomous and good agents of learning (Bursali, 2018).

Self-Regulation and Online Learning Self-Efficacy

The variables of SE are said to have significantly meaningful correlations with SR, and both influence each other positively (Cho & Cho, 2017; Sungur & Tekkaya, 2006 as cited in Sen & Yilmaz, 2016; Tosuncuoglu, 2019). Self-regulated learning has been considered a comprehensive and holistic approach that influences SE and learning achievement (Yoon et al., 2014 & Zimmerman et al., 1996, as cited in Lai et al., 2018; Tosuncuoglu, 2019). Self-regulated learners are expected to have higher achievements and better outcomes, as they are more likely to develop high SE (Cho & Cho, 2017; Gurcay & Ferah, 2018). Likewise, SE is considered an important variable that promotes self-regulating behaviors (Lee et al., 2020; Tosuncuoglu, 2019).

Students with high SR and SE are more likely to reach the academic goals they have set for themselves, despite the difficulties they might encounter (Gurcay & Ferah, 2018). With this knowledge, education can be improved with consideration of students' actual motivations, rather than motivations imposed by educators that are meant to control the student's academic endeavors (Tosuncuoglu, 2019). It is important to understand the relationship between SR and SE to identify challenges regarding change and stasis in education (Tonsunguoglu, 2019). Despite the availability of online learning and the recent shift towards the new normal, a few existing literatures have identified whether there is an association between SR and OLSE.

Synthesis

The COVID-19 pandemic has greatly affected the educational system, forcing the "new normal" online learning upon students and teachers. With the shift into the new normal, setting goals, accomplishing assignments, and understanding the given material, may be complex challenges the students face. Nursing students may experience additional challenges as they are more vulnerable to stressors and psychological disturbances due to the highly competitive nature of nursing programs (American Association of College of Nursing, 2017, Levett-Jones et al., 2007, Ulrich & Lathlean, 2007, & Versaeval, 2014, as cited in Raymond & Sheppard, 2017; Shehadeh et al., 2020). This poses the question of whether nursing students can achieve academic goals and perform successfully on their own in the online learning environment. SR and OLSE are two important factors that predict student performance in the online learning environment. SR is related to goal setting and attaining, in which an individual can autonomously facilitate their learning by monitoring their progress and modifying their behavior accordingly (Delen & Liew, 2016; Fadda, 2019; Jakesova et al., 2016; Lin et al., 2016). In contrast, SE is an individual's perception of their capability to complete a task successfully (Bandura, 1997). Although there are existing studies on the association between SR and SE per se, only a few have been done on SR and OLSE among nursing students.

Methodology

Research Design

An analytical-correlational research design was utilized to examine the association between nursing students' SR and OLSE. No interventions occurred, nor did the researchers try to determine causation (Polit & Beck, 2011). The design has yielded one of the three possible results: a finding of no association, a positive correlation, or a negative correlation between nursing students' SR and OLSE (Tuckman & Harper, 2012).

Sample and Setting

The study involved nursing students aged 18 to 50 who were enrolled at Pampanga nursing colleges. Currently, two thousand and twenty-seven (2027) nursing students are attending the seven (7) nursing colleges in Pampanga (see Appendix C). OpenEpi.com (version 3.01) an open-access epidemiologic statistics software, was used to identify the sample size. A total of three-hundred twenty-four (324) nursing students attending colleges in Pampanga were yielded after factoring in a population of 2027 and hypothesizing a 50% frequency of outcome with a 95% confidence level (Dean et al., 2013).

Sampling Design

Since a sampling frame was not obtained due to the Data Privacy Act of 2012, respondent-driven sampling (RDS) was utilized. RDS is a method for drawing probability samples of "hidden" or "hard-to-reach populations" (Abdesselam et al., 2020, p. 6; Baraff et al., 2016, p. 5). RDS uses people's social networks, which underlies the hidden population, thus reducing threats to privacy as respondents might be asked directly for a list of contacts (Baraff et al., 2016). Sampling bias resulting from the non-randomness of the initial participants may be reduced by keeping track of the respondents' recruitment patterns and applying mathematical models to the recruitment process (Baraff et al., 2016; Hipp et al., 2019).

Instrument

Demographics

An online survey was used to obtain the participants' demographic information such as their age, gender, college major, college level (first year, second year, third year, or fourth year), and the institution they are enrolled in. The participants were asked to name the current dean of their department to verify that they attend the institution that they have listed. Among the correspondents, only nursing students 18 to 50 years old attending a college of nursing in Pampanga were included in the study.

Online Learning Self-Efficacy Scale (OLSES)

The Online Learning Self-Efficacy Scale (OLSES) is a 22-item scale designed to assess the OLSE of students with and without online learning experience (Zimmerman & Kulikowich, 2016). The tool is straightforward and simple; thus, students with and without an online learning experience can readily understand each item. It consists of three subscales: learning in the online environment, time management, and technology use. The respondents rated each of the tasks on the OLSES (see Appendix D) using a 6-point Likert-type scale, from 1 (could perform tasks poorly) to 6 (could perform tasks at an expert level). Zimmerman and Kulikowich (2016) examined evidence of convergent and divergent validity using correlational techniques. Results indicated that the measure was highly reliable in terms of internal consistency with a coefficient (Cronbach's alpha) of .987 (Yavuzalp & Bahcivan 2020). However, the tool also comes with a few drawbacks. The different psychological variables that can affect students' success together with SE perception were not identified on the scale as these are significant variables in university students' online learning environments (Yavuzalp & Bahcivan, 2020).

Short Self-Regulation Questionnaire (SSRQ)

The Self-regulation Questionnaire is composed of 63 items that assess the seven dimensions of SR proposed by Miller and Brown (1991, as cited in Carey et al., 2004): (1) information input, (2) self-evaluation, (3) instigation to change, (4) search for change, (5) planning for change, (6) implementation of strategies for change, and (7) goal attainment evaluation plan (Brown et al., 1999 as cited in Carey et al., 2004). SRQ can be particularly beneficial in the study of adolescent habits and within an education context. However, the instrument is composed only of students in secondary school. The author suggested including samples of adolescents who are not attending school or even those at risk of social exclusion (Pichardo et al., 2018, p 13).

Several studies have examined the SRQ's psychometric properties, yielding several factorial solutions that enabled the authors to propose a shorter version of questionnaire (Carey et al., 2004). According to the results, the short version of the Self-Regulation Questionnaire (SSRQ) is a viable alternative to the complete version (Pichardo et al., 2018). SSRQ is grouped into four factors: (1) goal setting, (2) perseverance, (3) decision making, and (4) learning from mistakes, which contain a total of 17 items scored in a Likert-type scale (see Appendix E) from 1 (strongly disagree) to 5 (strongly agree) (Pichardo et al., 2014). There is a high correlation between the SSRQ and the original SRQ, which supports the utility of the short version (Pichardo, 2014). The reliability of the items is interpreted as Cronbach's alpha with an acceptable internal consistency of $\alpha = .86$ for the total of questionnaire items (Pichardo, 2014). SR measured by the SSRQ contributes to the explanation of self-regulated learning (Goal setting and Learning from Mistakes) while remaining independent from grades. Since this type of SR is more closely connected to daily life than the academic context, there is not much research on the relationship between general SR of behavior and academic performance (Pichardo et al., 2014, p. 2).

Data Collection

RDS, a combination of a non-probability chain-referral design with a statistical model was utilized for the data collection process (Lavrakas, 2008). The data collection process started with the initial participants who served as seeds for an expanding chain of referrals. A convenience sample of undergraduate nursing students (the initial participants who served as seeds) was selected from different Pampanga institutions. The questionnaire was posted on the official social media accounts to allow acquaintances and the respondents to share the post among their social networks. This further disseminated the questionnaire and gathered more participants to take part in the study. The seeds received uniquely numbered codes and were tasked to recruit at least 3 participants for the next wave. The corresponding wave of participants were given the same tasks, and so on until the desired sample size was met. The social networks and recruitment patterns of each participant were kept track of. Afterward, mathematical models were applied to the recruitment process to weigh the sample and compensate for the non-randomness of the initial participants (Baraff et al., 2016; Hipp et al., 2019).

After identifying the convenience sample, the initial participants received an invitation email and a hyperlink to the research instruments. The web-based software "Google Forms" was used in collecting data. Once the instrument was accessed, the survey administration software redirected the participants to the background and purpose of the study and the informed consent. The informed consent constitutes the voluntary nature of participation, the specific expectations regarding participation, and the potential costs and benefits (see Appendix B). The consent form did not obtain any identifying information of each participant such as their name or contact number. Information concerning the stored data samples during the study was included in the consent form. The collected data will be secured within five years for different purposes, which include: (1) Giving access to information among researchers studying the same field; (2) Making information available to people who want to learn relevant topics about the study, as long as the authors are properly cited; and (3) Paving the way for the study's improvement by providing information among the readers who may serve as their bases. The data will be stored in a hard drive and a Dropbox to ensure safety and to serve as backups in case of technical problems. Only the researchers of this study will be granted access to the information stored in the aforementioned portals. After five (5) years of keeping this information, the data's hard and soft copies will be permanently disposed of, including any information regarding the study participants.

Data Analysis

Microsoft Excel was used to subject the data to descriptive (frequency distribution, central tendency, and variability) and inferential statistics (Pearson's correlation coefficient). Frequency distribution was used to obtain an overview of the demographic profile of the respondents and the occurrence of scores in SR and OLSE. The average SR and OLSE scores were measured using the mean to describe whether nursing students have high SR and OLSE. On the other hand, the standard deviation described how spread out the data was from the mean. A high standard deviation value indicated a greater spread; therefore, the mean did not summarize the data well. To analyze the pattern and strength of the association between SR and OLSE, Pearson's correlation coefficient was used. The closer the coefficient is to 1.00, the stronger the positive, or direct, association; the closer the coefficient is to –1.00, the stronger the negative, or inverse, association (see Appendix F). A hypothesis test of significance of the correlation coefficient was executed to determine whether the linear association in the sample data is strong enough to represent the association in the population data. The p-value was set at <.05 for determining the significance of the findings. If the test concludes that the correlation coefficient is significantly different from zero, then the correlation coefficient is "significant."

Ethical Considerations

The study was submitted to the Holy Angel University - Institutional Review Board for clearance. The participants assured of confidentiality, right to full disclosure, self-determination, non-maleficence, and justice. The nature of the study was disclosed to the participants, and they were informed that their participation was merely used for educational purposes. The findings of the study were shared with the participants before it was made public to allow them to examine the study themselves. An examination of nursing students' SR and OLSE may provide future researchers, nursing administrators, academic leaders, and the participants themselves insights into students' motivation, academic performance and expand knowledge about the two concepts. In adherence to the Data Privacy Act of 2012, the researchers had secured confidentiality and avoided data from being leaked by not requiring participants to include their names in any part of the survey. The data had no identifying information and were stored in a password-protected account. Participants were informed that participation is completely voluntary and that they can decline or withdraw at any time during the study. Moreover, to assure justice, the selection of participants was primarily based on research requirements considering the inclusion criteria and the objectives of the study.

Results

A total of one hundred sixty-seven (167) responses were collected from the online survey. Upon inspection, it revealed a duplicate entry and the researchers decided to exclude it from data analysis.

Table 1 lists the age, gender, college level, and institution of a total of one hundred sixty-six (166) nursing students who participated in the online survey. The majority of participants were age 18–20 (N=99; 60%), while sixty-five (65; 39%) were age 21-30, and two (2; 1%) were 31-40 years old. One hundred thirty-five (135; 81%) participants were female, thirty (30; 18%) male, and one (1; 1%) identified as non-binary. As for college level, thirty-five (35; 21%) were first-year students, fifty-two (52; 31%) were second-years, and the majority were third-year students (79; 48%). Examining the distribution of institutions, out of a total of 166 participants, the majority attended Holy Angel University (N=62; 37%), followed by Angeles University Foundation (N=44; 27%), Guagua National Colleges (N=27; 16), University of the Assumption (N=20; 12%), Our Lady of Fatima University (N=7; 4%), College of Our Lady of Mt. Carmel (N=4; 2%), and Systems Plus College Foundation (N=2; 15).

Table 1

Demographic Profile of the online sample of nursing students (N = 166)

	N (%)	Mean (=SD)
Age		**20.43 (=1.76)**
18-20	99 (60)	
21-30	65 (39)	
31-40	2 (1)	
Gender		
Female	135 (81)	
Male	30 (18)	
Non-Binary	1 (1)	
College Level		
First year	35 (21)	
Second year	52 (31)	
Third year	79 (48)	
Fourth year	0 (0)	
Institution		
Angeles University Foundation	44(27)	
College of Our Lady of Mt. Carmel	4(2)	
Guagua National Colleges	27 (16)	
Holy Angel University	62 (37)	
Our Lady of Fatima University	7(4)	
Systems Plus College Foundation	2(1)	
University of the Assumption	20(12)	

Table 2 shows whether nursing students have a high SR and OLSE, as well as how far the data is from the mean. The study included a total of 166 nursing students from Pampanga. The results revealed that nursing students have a moderate SR (x=54.75, SD=10.60) and OLSE (x=93.01, SD=25.03).

Table 2

SR and OLSE - Mean Scores

	M	SD
SR	54.75	10.60
OLSE	93.01	25.03

Note. N = 166; Highest Possible Score (HPS) for OLSE: 132; HPS for SR: 85

Table 3 shows the correlation among nursing students' SR and OLSE. Pearson correlation coefficient was used to examine the association between nursing students' SR and OLSE. The results indicated a strong positive association between nursing students' SR and OLSE (r=.60, p<.00). This implies that the Pearson's correlation coefficient r = .60 with N of 166 is statistically significant at 0.05 level. Thus, the null hypothesis that "there is no association between nursing students' SR and OLSE" is not accepted. In other words, there is an association between nursing students' SR and OLSE.

Table 3

Pearson Correlation Between SR and OLSE

		SR	OLSE
SR	Pearson Correlation	1	0.59647645
	Sig. (2-tailed)		<0.001
	N	166	166
OLSE	Pearson Correlation	0.59647645	1
	Sig. (2-tailed)	<0.001	
	N	166	166

Discussion

The K to 12 program, which covers kindergarten and 12 years of basic education, was implemented in the school year 2012 to 2013. The first batch of high school students who underwent in the K to 12 program did not graduate until March of 2018 (Official Gazette, n.d., para 1) which explains the absence of fourth-year nursing students. The analysis revealed that the majority of the participants were female. This finding is supported by WHO (2020b), in which they reported that the nursing workforce is predominantly female. In South-East Asia, 89% of nursing personnel are female, while only 11% are male (World Health Organization, 2020b).

The data analysis results revealed that nursing students have a moderate level of SR. Students who have better SR could have better educational performance as it enhances emotion, SE, planning, and motivation to improve in an academic setting (Sahranavard et al., 2018). Some studies suggest that college students are effective self-regulators as they have great control of their own schedule and how they approach their academic tasks and learning, while others show that they are not (Peverly et al., 2003; Xiao et al., 2019). Several studies in Asia revealed that college students have low to moderate SR (Ajisuksmo & Vermunt, 1999; Chen & Lin, 2018).

According to the study of Chen & Lin (2018), there is a decrease in SR throughout the college span, which appears to be an ultimate problem among Taiwanese college students, including nursing students. It has been suggested that the dimensions of SR may differ depending on the participants' groups and culture (Garzón Umerenkova et al., 2017, Vosloo et al., 2013, as cited in Chen & Lin, 2018). Regardless, integrating SR skills into the learning processes makes students more independent and responsible for their learning (Sahranavard, 2018, para. 20).

The data regarding OLSE suggest that nursing students have a moderate level of OLSE. The online learning platform led people to many opportunities as today's learners have grown up under the influence of the internet, and the majority of the students are well familiarized with using technology that the learner's academic performance is influenced by learner's SE (Honicke & Broadbent, 2016). In the study of Alqurashi (2018), the results indicate that OLSE is a critical factor in student satisfaction and perceived learning in an online learning environment. Several studies have found that SE is an important predictor of learners' satisfaction in an online learning environment (Wang & Newlin, 2002; Lim, 2001, as cited in Hodges, 2008). Similarly, the results in a study about the relationship between OLSE and student satisfaction indicate that the strongest predictor of a student's satisfaction in an online learning environment was SE to complete online courses and SE to interact with instructors (Shen et al., 2013). In this context, more studies are needed as there is little known information about SE in an online learning environment (Hodges, 2008). As found in the literature, studies about the role of SE in online education are focused on the technological aspects of SE in online learning (Kundu, 2020) such as learning management system (LMS) SE (Martin et al., 2010; Prior et al., 2016), internet SE (Kuo et al., 2014; Lin et al., 2013), computer SE (Pellas, 2014), digital media SE (Pumptow & Brahm, 2020) and many more.

The analysis revealed that nursing students' SR is significantly associated with their OLSE. In fact, the results show a strong positive association between nursing students' SR and OLSE. This finding supports the study results conducted on 780 undergraduates (sophomores and juniors) from the U.S. Naval Academy by Artino and McCoach (2008), in which their OLSE subscale was positively correlated with metacognitive SR. Due to the relatively little research conducted on the association between SR and OLSE, there is limited literature to support the results. However, other studies in the literature suggest a positive and significant relationship between SR and SE for learning (Agustiani et al., 2016; Cho & Shen, 2013 as cited by Cho & Cho, 2017; Sen & Yilmaz, 2016). Meanwhile, a study on African American students enrolled in two undergraduate-level online research courses revealed a positive and significant correlation between internet SE and SR (Kuo et al., 2020). Students with high SE engage more in setting their own goals, monitoring their learning, performing different learning strategies, and evaluating their own progress, all of which are components of SR (Duchatelet & Donche, 2019; Sen & Yilmaz, 2016).

As a matter of fact, the forethought phase of SR includes task analysis and self-motivational beliefs (Artino & McCoach, 2008). Self-motivational beliefs include SE, outcome expectation, intrinsic value, and goal orientation (Metsärinne, 2014; Türkben, 2019).

Limitations

While this study sought to explore nursing students' behavioral aspects of online learning, there are a few limitations worth noting. First, by means of sampling design, an attempt to execute RDS was made, but follow-up and monitoring of referrals proved to be difficult due to the current setup brought about by the pandemic. Under such circumstances, participants were identified using a snowball sampling technique. Second, reaching the suitable sample size for the study was not successful as the response rate is rather low among nursing students who could potentially make up the target sample group, and the online nature of the data collection disproportionately affects students with low socioeconomic status. Based on these factors, selection bias may occur, limiting the generalizability of the study findings. Lastly, cross-sectional studies have low internal validity, the causal inference might be difficult to obtain, and the results might not be the same in the subsequent years as the gathered information only represents what is going on at one point in time (Carlson & Morrison, 2009; Levin, 2006; Setia, 2016).

Conclusion

The objectives of this research were to determine and describe whether there is an association between nursing students' SR and OLSE. Nursing students in Pampanga were found to have a moderate level of both SR and OLSE. The study also revealed that there is a statistically significant and strong positive association between SR and OLSE. With that, the academic administration and nurse educators should explore the dynamics between the two variables and develop programs that may improve SR and OLSE.

Recommendations

Several limitations of the study were present, suggesting future research directions. To our knowledge, this is also the first paper done on the association between SR and OLSE, specifically among nursing students. Thus, further exploration on the topic must be done to expand the available literature and fill in the gaps within this particular phenomenon. Considering that more undergraduate and graduate degree programs have been offered online, replication of the study in a different group of participants either from a different region or from various regions, should be conducted. Doing so would not only allow a comparison of the association between SR and OLSE among various college students but also reveal how the levels of SR and OLSE vary between students in different programs. A time series may also be conducted to examine if the results are consistent over time. By conducting a time series, researchers can also explore what factors influence change among SR and OLSE. Since the current literature mostly focuses on academic SE, researchers may also include this variable in their study to compare how it differs from OLSE. Moreover, researchers can compare how the association between SR and academic SE differs from the association between SR and OLSE.

The results of this study may be beneficial to nurse educators, academic administration, and nursing students. Since the results reveal a strong positive association between SR and OLSE, the academic administration and nurse educators should explore the dynamics between the two variables. Moreover, the academic administration and nurse educators should also consider including activities that improve SR and OLSE. Some studies suggest that SR is positively related to and is one of the predictors of student performance (Delen & Liew, 2016; Kuo et al., 2020; Sahranavard et al., 2018). Students with high levels of SR can produce better educational outcomes (Delen & Liew, 2016; Sahranavard et al., 2018). Therefore, nursing students should develop an awareness of their SR and OLSE and actively participate in improving these variables.

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APPENDIX A

Study Instrument

I. Demographic

Age:___________________
Gender: ( ) F ( )M
College Major:___________________
College level: ( )1st year ( ) 2nd year ( ) 3rd year ( ) 4th year
Institution:
( ) Angeles University Foundation
( ) College of Our Lady of Mt. Carmel Guagua National Colleges
( ) Holy Angel University
( ) Our Lady of Fatima University
( ) Systems Plus College Foundation University of Assumption
( ) Other:
Dean of the department: ____

II. Online Learning Self-Efficacy Scale

	Perform tasks poorly	**Perform tasks below average**	**Perform tasks on average**	**Perfo rm tasks above average**	**Perform tasks eminently good**	**Perform tasks at an expert level**
1. Navigate online course material efficiently	1	2	3	4	5	6
2. Find the course syllabus online	1	2	3	4	5	6
3. Communicate effectively with my instructor via e- mail	1	2	3	4	5	6
4. Communicate effectively with technical support via e-mail, telephone, or live online chat	1	2	3	4	5	6
5. Submit assignments to an online drop box	1	2	3	4	5	6
6. Overcome technical difficulties on my own	1	2	3	4	5	6
7. Navigate the online grade book	1	2	3	4	5	6
8. Manage time effectively	1	2	3	4	5	6
9. Complete all assignments on time	1	2	3	4	5	6

	Perform tasks poorly	Perform tasks below average	Perform tasks on average	Perfo rm tasks above average	Perform tasks eminently good	Perform tasks at an expert level
10. Learn to use a new type of technology efficiently	1	2	3	4	5	6
11. Learn without being in the same room as the instructor	1	2	3	4	5	6
12. Learn without being in the same room as other students	1	2	3	4	5	6
13. Search the Internet to find the answer to a course-related question	1	2	3	4	5	6
14. Search the online course materials	1	2	3	4	5	6
15. Communicate using asynchronous technologies (discussion boards, e-mail, etc.)	1	2	3	4	5	6
16. Meet deadlines with very few reminders	1	2	3	4	5	6
17. Complete a group project entirely online	1	2	3	4	5	6
18. Use synchronous technology to communicate with others (such as Skype)	1	2	3	4	5	6
19. Focus on schoolwork when faced with	1	2	3	4	5	6
20. Develop and follow a plan for completing all required work on time	1	2	3	4	5	6
21. Use the library's online resources efficiently	1	2	3	4	5	6

	Perform tasks poorly	Perform tasks below average	Perform tasks on average	Perfo rm tasks above average	Perform tasks eminently good	Perform tasks at an expert level
22. When a problem arises ask questions in the appropriate forum (e-mail, discussion board, etc.)	1	2	3	4	5	6

III. Short Self-Regulation Questionnaire

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I usually keep track of my progress toward my goals	1	2	3	4	5
2. I have a hard time setting goals for myself	1	2	3	4	5
3. I have trouble making plans to help me reach my goals	1	2	3	4	5
4. I set goals for myself and keep track of my progress	1	2	3	4	5
5. Once I have a goal, I can usually plan how to reach it	1	2	3	4	5
6. If I make a resolution to change something, I pay a lot of attention to how I'm doing	1	2	3	4	5
7. I get easily distracted from my plans	1	2	3	4	5
8. I have a lot of willpower	1	2	3	4	5
9. I am able to resist temptation	1	2	3	4	5
10. I have trouble making up my mind about things	1	2	3	4	5
11. I put off making decisions	1	2	3	4	5
12. I have so many plans that it's hard for me to focus on any one of them	1	2	3	4	5
13. When it comes to deciding about a change, I feel overwhelmed by the choice	1	2	3	4	5
14. Few problems or distractions throw me off course	1	2	3	4	5
15. I don't seem to learn from my mistakes	1	2	3	4	5
16. I usually only have to make a mistake one time in order to learn from it	1	2	3	4	5
17. I learn from my mistakes	1	2	3	4	5

APPENDIX B

Sample Informed Consent

Sample Consent Form for the online survey

You are invited to participate in a web-based online survey on "Association between Nursing Students' Self-Regulation and Online Learning Self-Efficacy". This is a research project being conducted by Level III nursing students from the School of Nursing and Allied Medical Sciences of Holy Angel University: Monica L. Borja, Ericka C. Munsayac, Steffanie A. Serrano and Joergiana V. Silang. It should take approximately 10 minutes to 15 minutes to complete the prepared instrument through this Google form.

I. THE STUDY

An analytical-correlational research design will be utilized to examine the association between nursing students' self-regulation and online learning self-efficacy. The study needs at least three-hundred twenty-four nursing students currently enrolled in a college of nursing in Pampanga. The results of the study will be helpful for future researchers, nursing administrators and instructors, and the participants themselves in finding interventions to improve both SR and OLSE. Nursing education administrators and leaders may use the results to improve their curriculum and lessons in a way that empowers SR and OLSE among nursing students. Furthermore, the results can help students recognize opportunities to set goals and guidance in SR and OLSE.

II. PARTICIPATION

Your participation in this survey is completely voluntary. You may refuse to take part in the research or exit the survey at any time without penalty. You are free to decline to answer any particular question you do not wish to answer for any reason. You must also be 18 to 50 years old or older at the time of your involvement in the study. You must also identify as a student enrolled in the Bachelor of Science in Nursing in an institution in Pampanga. You must be currently residing in the Philippines.

III. DURATION

The data collection will be primarily confined to the completion of this survey form. If you decide to opt in, for follow up questions and interview, then the research will span six (6) months in total. The data, however,
will be kept five (5) years after the study has been published.

IV. BENEFITS

You will receive no direct benefits from participating in this research study. However, you will be provided the results of the study, so that you can examine them for yourself and gain insight of the association between self-regulation and online learning self-efficacy.

V. RISKS
The possible risks or discomforts of the study are minimal.

VI. CONFIDENTIALITY

Your survey answers will be sent to a link at Google Drive where data will be stored in a password protected electronic format. Google Drive does not collect identifying information such as your name, email address, or IP address. Therefore, your responses will remain anonymous. No one will be able to identify you or your answers, and no one will know whether or not you participated in the study. A Data Storage Policy is included in this informed consent form.

If you choose to provide contact information such as your phone number or email address, your survey responses may no longer be anonymous to the researcher. However, no names or identifying information would be included in any publications or presentations based on these data, and your responses to this survey will remain confidential.

VII. SHARING THE RESULTS

Nothing that you disclose today will be shared with anybody outside the relevant individuals, and nothing will be attributed to you by name. The knowledge that we get from this research will be shared with you and your community before it is made widely available to the public. Each participant can opt to receive a summary of the results. Following the distribution of summary findings, the results may be published in reputable journals so that other interested people may learn from the research.

VIII. CERTIFICATE OF CONSENT

If any of the data, I have provided for this research project is unused or leftover when the project is completed (Tick one choice from each of the following boxes)

- ☐ I wish my data sample to be destroyed immediately.
- ☐ I want my data sample to be destroyed after three (3) years.
- ☐ I give permission for my data sample to be stored indefinitely

AND (if the sample is to be stored)

- ☐ I give permission for my data sample to be stored and used in future research but only on the same subject as the current research project: Association between Nursing Students' Self-Regulation and Online Learning Self-Efficacy.
- ☐ I give my permission for my data sample to be stored and used in future research of any type which has been properly approved.
- ☐ I give permission for my date sample to be stored and used in future research except for research about Self-Regulation and Online Learning Self-Efficacy

AND

☐	I want my identity to be removed from my data sample.
☐	I want my identity to be kept with my data sample.

If you have questions at any time about the study or the procedures, you may contact, Joergiana Marie V. Silang, via email at: jvsilang@student.hau.edu.ph

X. CONTACT INFORMATION FOR QUESTIONS ABOUT YOUR RIGHTS AS A RESEARCH PARTICIPANT

The Holy Angel University Institutional Review Board approved this research study:

Protocol Number: 2021-006-JVSILANG-OLSELFEFFICACY

You may contact the Holy Angel University Institutional Review Board if you have questions about your rights, concerns, complaints or comments as a research participant.

Holy Angel University
Holy Angel University Institutional Review Board Graduate School Office, 5th Flr
Peter G. Nepomuceno Center for Professional Development Bldg, Holy Angel University, Angeles City
Phone: (045) 888-8691 to 93 local 1534 Email: irb@hau.edu.ph

ELECTRONIC CONSENT: Please select your choice below. You may print a copy of this consent form for your records. Clicking on the "Agree" button indicates that

- You have read the above information
- You voluntarily agree to participate
- You are 18 years of age or older

I have read the information, or it has been read to me. I consent voluntarily to have my samples stored in the manner and for the purpose indicated above.

( ) Agree

( ) Disagree

APPENDIX C

Population and Sample Size of Student Nurses in Pampanga

School	Population
Angeles University Foundation	814
College of Our Lady of Mt. Carmel	48
Guagua National Colleges	97
Holy Angel University	203
Our Lady of Fatima University Systems Plus College Foundation	500
University of Assumption	134
Total	231
Sample Size: 324	2027

APPENDIX D

Online Learning Self-Efficacy Scale

OLSES item stems
1. Navigate online course materials efficiently
2. Find the course syllabus online
3. Communicate effectively with my instructor via e-mail
4. Communicate effectively with technical support via e-mail, telephone, or live online chat
5. Submit assignments to an online drop box
6. Overcome technical difficulties on my own
7. Navigate the online grade book
8. Manage time effectively
9. Complete all assignments on time
10. Learn to use a new type of technology efficiently
11. Learn without being in the same room as the instructor
12. Learn without being in the same room as other students
13. Search the Internet to find the answer to a course-related question
14. Search the online course materials
15. Communicate using asynchronous technologies (discussion boards, e-mail, etc.)
16. Meet deadlines with very few reminders
17. Complete a group project entirely online
18. Use synchronous technology to communicate with others (such as Skype)
19. Focus on schoolwork when faced with distractions
20. Develop and follow a plan for completing all required work on time
21. Use the library's online resources efficiently
22. When a problem arises, promptly ask questions in the appropriate forum (e-mail, discussion board, etc.)

APPENDIX E

Short Self-Regulation Questionnaire

SSRQ items with their factor	
Factor	**Item Statement**
F1	1. I usually keep track of my progress toward my goals. 2. I have a hard time setting goals for myself. 3. I have trouble making plans to help me reach my goals. 4. I set goals for myself and keep track of my progress 5. Once I have a goal, I can usually plan how to reach it. 6. If I make a resolution to change something, I pay a lot of attention to how I'm doing.
F2	7. I get easily distracted from my plans. 8. I have a lot of willpower. 9. I am able to resist temptation.
F3	10. I have trouble making up my mind about things. 11. I put off making decisions. 12. I have so many plans that it's hard for me to focus on any one of them. 13. When it comes to deciding about a change, I feel overwhelmed by the choice. 14. Few problems or distractions throw me off course.
F4	15. I don't seem to learn from my mistakes. 16. I usually only have to make a mistake one time in order to learn from it. 17. I learn from my mistakes.
F1, goal setting; F2, perseverance; F3, decision-making; F4, learning from mistakes	

APPENDIX F

Pearson's Correlation Coefficient Interpretation

Pearson's Correlation Coefficient Interpretation	
r value	**Interpretation**
≥ .70	Very strong positive relationship
.40 to .69	Strong positive relationship
.30 to .39	Moderate positive relationship
.20 to .29	Weak positive relationship
.01 to .19	No or negligible relationship
0	No relationship (zero correlation)
-.01 to –.19	No or negligible relationship
-.20 to -.29	Weak negative relationship
-.30 to -.39	Moderate negative relationship
-.40 to -.69	Strong negative relationship
≤-.70	Very strong negative relationship

Pedagogical Purposes of Using Open Educational Resources in STEM Education: A Case Study in a STEM High School in Egypt

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Abstract

Science, technology, engineering, and mathematics (STEM) schools in less advanced countries are challenged to maintain students' motivation and interest in STEM fields mainly due to a lack of suitable materials and teacher competence. In a context where STEM teachers generally lack the capacity to design and develop good instructional materials, utilizing existing quality open educational resources (OER) as instructional materials can be an effective way to support STEM education at little or no additional cost. This study explored how and why STEM teachers in a less advanced country, where teaching and learning materials are lacking and the students' interest in STEM is generally low, utilize OER. Qualitative research particularly, a case study, was conducted through interviews with six (6) teachers and nine (9) students in a STEM high school in Egypt, and through class observations and syllabi analysis. The analysis revealed that STEM teachers utilized a variety of OER predominantly for three pedagogical purposes, namely: promoting and maintaining students' interest in STEM fields, seeking information needed for learning, and developing student competencies required in the STEM workforce. Findings suggest that OER can be effectively employed, for promoting student motivation and providing subject content in less advanced countries. OER plays an important role as a substitute for textbooks, positively impacting students' active learning and competency building.

Keywords: *motivation, open educational resources (OER), pedagogical purposes, STEM education*

Introduction

Development of STEM education and challenges

Recognizing the importance of the STEM workforce, advanced countries have dedicated a lot of attention and effort towards implementing robust STEM educational strategies and preparing students to enter the STEM workforce. A prime example is the USA where STEM has been recognized as the cutting edge in policy agenda (The Committee on STEM Education, 2018). In Europe, it has been a European Commission's key policy since 1990 and several Western European countries have also emphasized on STEM for framing educational and industrial national policies (Blackley & Howell, 2015).

The K-12 STEM schools were established to promote STEM education and provide a unique learning environment with an advanced integrated curriculum, professional teachers, training opportunities, and immersion in real-life situations. As reported by Erdogan and Stuessy (2015), STEM school students tend to perform better in mathematics and science tests in comparison with students from traditional schools. The main feature of the STEM education curriculum worldwide is the subject integration between science, technology, engineering, and math (Bybee, 2010). However, the idea of curriculum integration is not as easy as putting different subject areas altogether as it is more complex and challenging (Wang et al., 2011). There is no clear framework or approach among all countries on how to integrate the four subjects together (Bell, 2016). Each country integrates differently according to its national education policy. Despite those differences, the method and practice of teaching, or pedagogy, is almost the same (Carter, 2013). In STEM, project and problem-based learning is the primary pedagogy where students learn through a real-world situation. According to Tsupros et al (2009), it is better than learning atomistically. This transition from traditional classroom setting, which is teacher-centered, to student-centered approach and from the view that a student is not just a consumer, but a co-producer is essential for cultivating a STEM independent learning environment. However, despite their success, STEM schools have faced challenges, most noticeably, with maintaining students' motivation and interest (American National Governor's Association, 2007; Young et al., 2017).

A number of less advanced countries have addressed STEM issues within their public education system by focusing on developing qualified teachers in the areas of science and technology (Marginson et al., 2013), but a lack of solid policies and action plans at the national level, leading to lower achievement in STEM education with a lack of quantity and quality in their STEM workforces is still observed (Passey et al., 2016). World recognition of science and technology for socio-economic development has created a climate for strengthening STEM education in less advanced countries (Kennedy & Odell, 2014; UNESCO, 2002). In addition, several attempts to promote STEM education at state and national levels have been observed, especially in Egypt (Charlifue, 2018; Omran, 2019), Brazil (Horta, 2013), Sri Lanka (Kumara, 2019), Ethiopia (UNESCO, 2017), and Russia (Smolentseva, 2013).

Labov et al. (2010) and Sanders (2008) argued that the goal of STEM education is to support students in learning to apply the basic content and practices of STEM disciplines to situations they encounter in life. However, despite considerable momentum in recent years, achieving the goal remains a significant challenge facing education communities, especially in less advanced countries. Achieving the goal requires educators to provide students with experience in applying knowledge and skills to real-life through an interdisciplinary approach integrating the four STEM components (Bybee, 2013; Ryu et al., 2019). Further, STEM educators must develop well-designed instructional materials (Shernoff et al., 2017) and implement high-quality teaching practices (Ejiwale, 2013).

Possibilities of OER in addressing STEM challenges

It is recognized that good instructional materials aid in preparing students for real-life while maintaining their interest in the STEM fields. In a less advanced country, where STEM teachers generally lack the capacity to design and develop good instructional materials, utilizing high quality open educational resources (OER), as instructional materials, is an effective way in supporting STEM education at little or no additional cost.

The term *OER*, developed during the 2002 UNESCO Forum on the Impact of Open Courseware for Higher Education in Developing Countries (UNESCO, 2002), is defined as "teaching, learning, and research resources with an intellectual property license that permits them to be reused, reworked, remixed, and redistributed" (D'Antoni, 2009). Such resources are often in the form of video clips, images, audio files, newspaper articles, online quizzes, and multimedia (Jung & Hong, 2016; Rahayu & Sapriati, 2018) and can be freely modified according to specific instructional needs and conditions. The goal of OER is the creation of universally accessible educational materials offered freely and openly to be used in teaching, learning, and research for educators and learners (Bissell, 2009). This open learning environment positively influences student motivation (Kew et al. 2018) and helps develop critical thinking skills (Rahayu & Sapriati, 2018), technology skills (Tsai, 2018), and soft and academic skills (Pitt et al., 2013).

Recognizing the varied benefits and rapid growth of OER, some teachers encourage their students to use OER as supplementary materials. Others employ open textbooks to save their students some money. On the other hand, some academic institutions go as far as providing credits to their students who use free online resources and materials in order to gain the knowledge they need to acquire competency in specific areas (Smith & Casserly, 2006). The purpose of using OER differs depending on the types of OER adopted, the pedagogical benefits that teachers recognize in adopting OER, and the motivational and learning advantages perceived by students in using OER.

As a result of its adoption by educators and researchers in higher education, several pedagogical benefits of OER have been identified. In Canada, OER was used to develop ideas and inspiration for students to supplement existing coursework, together with preparation prior to actual teaching (Jhangiani et al., 2016). Jung and Hong (2016) found that OER provided better content and promoted active and deeper learning (effectiveness aspect), as well as gained and maintained attention and interest through the use of multimedia and hyperlinks (appeal or motivation aspect).

To date, there have been a limited number of studies conducted on the integration of OER and its pedagogical benefits in the context of STEM education. Ryu et al. (2019) investigated how preservice teachers in the USA utilized and modified online resources in an integrated STEM class and found that hands-on science experiments, existing integrated STEM lesson plans, scholarly research relevant to the selected lesson topics, and contextual information from newspapers were often employed in the STEM class. Yang (2017), in a study investigating the experience of graduate students when utilizing various forms of instructional materials in a STEM online course in the USA, found that besides the materials provided, the majority of the students used other online resources to help understand the content. While these studies help STEM teachers and students in understanding the overall use of free materials on the Internet, they do not address important questions such as what types of OER are being used in STEM schools and how these are being integrated into the classes to improve teachers' pedagogical practices, especially in the context of less advanced countries.

Objectives

The aim of this research was to investigate the pedagogical purposes of using OER in STEM education in a STEM school in Egypt that was selected as a case study. The following questions were posed:

1. What types of OER are used by teachers in the STEM school?
2. What are the pedagogical purposes of OER as employed by teachers in the STEM teaching process?
3. How are OER integrated with the teaching and learning process according to each pedagogical purpose?

Methodology

A case study was employed to allow researchers to examine, descriptively and heuristically, a phenomenon or case within a specific context (Merriam, 1998). The case study's main characteristics were research questions posed directly to teachers, and observations in natural classroom settings were conducted (Yin, 2014).

The case

A boarding school, established in 2014 as one of 14 STEM high schools in Egypt, was chosen as the case study. Similar to the other 13 STEM schools in Egypt, the school follows common features found in specialized STEM schools across the USA. In 2018, it had 301 enrolled students and 25 teachers. The maximum capacity of a STEM class was set at 25 students. Biology, Chemistry, Earth Science, Mathematics, and Physics formed the STEM subjects, and Arabic, English, and either French or German were the non-STEM subjects. Students also undertook some elective subjects such as Computer Science and Physical Education, with most subjects taught in English. The total grade for each subject is comprised of two parts. The first 40% is given to the exam scores and attendance, and the remaining 60% is allotted to the capstone project, a measurement of how students applied the subject in analyzing and solving a real-world problem. Students worked in teams from the beginning of the semester until the final presentation to analyze one of Egypt's real-world challenges before coming up with their solutions.

Participants

Six (6) teachers and nine (9) students agreed to participate in the study. By applying purposive sampling, the teachers were selected with consideration to subject taught, gender, and years of teaching experience (see Table 1), and three (3) students were selected from each grade (see Table 2).

Table 1

Teacher Participants in the Study

Code	Teaching Experience before STEM	Teaching Experience in STEM	Gender	Subject Taught
T1	6	5	F	Physics
T2	23	5	M	Math
T3	9	5	M	English
T4	25	4	M	Geology
T5	27	3	F	Chemistry
T6	9	5	M	Biology

Table 2

Student Participants in the Study

Code	Grade	Gender
S1	Grade 12	M
S2	Grade 12	M
S3	Grade 12	F
S4	Grade 11	M
S5	Grade 11	M
S6	Grade 11	F
S7	Grade 10	F
S8	Grade 10	F
S9	Grade 10	F

Data collection

After the approval from the Research Ethics Committee of the researchers' institution for sufficient consideration to participants' sense of dignity, respect for their human rights, and protection of their personal information, interviews with teachers and students, along with classroom observations and syllabi analysis, for the purpose of data triangulation, were conducted between September and October 2018. The researchers, as observers, provided an outsider's unbiased and impartial approach during data collection.

An open-ended semi-structured interview in Arabic was conducted and recorded with the six (6) teachers and the nine (9) students. The interview with teachers consisted of two parts: 1) questions relating to types of OER often used by the teacher in class, including ways and extent to what type of OER is utilized during the teaching process, and 2) questions clarifying the pedagogical purposes and the challenges faced when using OER and the types of OER having the largest impact on student motivation. Other questions also emerged during the course of the interview. The interview with students consisted of six (6) questions on learning while integrating OER in their sessions and their perceived learning outcomes. Student interviews were used to confirm and triangulate data collected from teacher interviews.

The Technology Integration Observation Protocol (TIOP), developed by Maxfiled et al. (2011) was employed, with the authors' permission, for observations to assess classroom activities and interactions, both among and between students and the teacher, together with how technology is integrated, what technologies are used, and the level of integration achieved with the curricular objective. To observe accurately and descriptively the extent to which OER was employed and integrated into the classroom environment, and to confirm the teachers' self-reported information given in the interviews to avoid over-reporting the amount of OER in use, two 80-minute direct observations were conducted in the classrooms of the interviewed teachers. The researcher's observation journal, using TIOP, followed a low inference descriptors strategy, allowing for precise, almost literal detailed descriptions of people and situations without any evaluation (Bashir et al., 2008).

The course syllabi of the six teachers were analyzed to identify the following: types of the OER listed, main teaching and learning activities employed, and expected skills gained for each session. With this, additional information gathered from the interviews and observations were confirmed and refined.

Data analysis

The interview data collected from the teachers were analyzed through a three-phased open coding approach characterized by merging all the concepts from the raw data and grouping them into conceptual categories (Khandkar, 2009). First, at the preparation stage, recordings of interviews were transcribed and translated into English, and data files were organized and labeled. Then, at the data reduction and exporting stage, irrelevant interview question responses were eliminated before all the remaining data were exported into NVivo 12 pro qualitative research software. Finally, at the coding and thematizing stage, coding schemes were generated. The unit of data analysis was phrased with one idea as a chunk. After carefully reviewing the coded data, tentative labels for data chunks were created and grouped as sub-categories and again refined. Three primary themes or pedagogical purposes emerged from the chunks: maintaining motivation, seeking information, and developing students' competencies (see Table 3).

The nine (9) codes found under the pedagogical purpose of maintaining motivation were compared to the motivational strategies of four dimensions of Attention, Relevance, Confidence, and Satisfaction (ARCS) model of motivation for exploring to what extent teachers are utilizing OER to motivate students. ARCS model is a motivational design helping teachers identify problems with student motivation and design strategies which can be used to make instruction match the interests and needs of students according to its four dimensions (Keller, 2010). It has been widely validated as a method for systematic improvement of learner motivation and performance in e-learning settings. This comparison explored in what way using OER as instructional materials in teaching and learning in STEM schools can determine students' motivation.

Interview data collected from the students were analyzed to confirm the themes that had emerged from the teachers' interviews. After reviewing students' stories and their daily experiences with OER, a narrative analysis was conducted manually to explore students' approaches to their use of OER.

Classroom observation was analyzed. From the protocol answers, the types of OER used in classrooms were listed and compared with teachers' interviews. Key themes were then identified throughout the protocol answers, together with the researcher's observation journal, to help describe the mode of OER integration inside each classroom.

Prior to teacher interviews and class observations, the six syllabi were examined individually to get a basic understanding of each class topic and important components for class activities. In addition, the syllabi analysis reflection journal was written to identify the types of OER mentioned in the syllabus and how each type of OER related to a specific activity.

Results

Types of OER used in STEM education

The teachers employed several types of OER throughout the STEM teaching and learning process. Based on the teacher' interviews, as confirmed by student interviews, classroom observations, and syllabi analysis, four main types of OER were used in STEM sessions. These included: 1) pdf references used as online textbooks, 2) videos, 3) educational websites, and 4) online quizzes. Additional materials, such as massive open online courses (MOOCs) and references made from Google Scholar were introduced to students.

The predominant type of STEM session OER was online textbooks. Pdf references were directly downloaded from the Internet to be used as textbooks by the students. Moreover, students were given the freedom to study either from the textbook references listed in the syllabus or to search alternative online references. A number of the references included in the syllabi were made available in the library as hardcopy books.

Videos were the next most popular OER. Videos were used daily, primarily to assist students in comprehending concepts presented in STEM classes. The primary source of videos was YouTube; however, the teachers also used other websites to broadcast instructive animations and documentary videos, such as the university's own or those from educational organizations. Videos from Khan Academy were played in a mathematics class to assist pupils in better understanding mathematical concepts.

Online sites for simulations of statistics and calculations were also referenced. Geogebra, an open software that dynamically integrates geometry, algebra, spreadsheets, graphing, statistics, and calculus for all grade levels, was frequently used for supplementary material.

Online quizzes, such as those offered by CliffsNotes, were sometimes used in addition to the quizzes found on Google Drives.

Pedagogical purposes of OER use

From the analysis of teacher interviews on the pedagogical purposes of OER use, 107 chunks were identified and categorized as follows: 1) maintaining motivation, 2) seeking information, and 3) developing student competencies (see Table 3). These findings were confirmed with data collected from the students' interviews, classroom observations, and syllabi analysis.

Table 3

Categorization of Pedagogical Purposes of Using OER inside STEM Sessions

Categories of Pedagogical Purposes	Sub-categories	Codes
Maintaining Motivation (47 chunks-44%)	Support linking to real-life application (15 chunks)	1. Real-life connections (9 chunks) 2. Project-based learning (6 chunks)
	Bringing excitement to the session (14 chunks)	3. Visual media attention (9 chunks) 4. Varieties (5 chunks)
	Supporting a well-planned session (9 chunks)	5. Time management (3 chunks) 6. Brainstorming (3 chunks) 7. Session closure (1 chunk)
	Encouraging students' engagement (9 chunks)	8. Challenges (5 chunks) 9. Activities (4 chunks)
Seeking Information (43 chunks-40%)	Teaching STEM content (33 chunks)	10. Achieving learning outcomes (12 chunks) 11. Confirming and expanding content understanding (11 chunks) 12. Pinpointing the main concept (10 chunks)
	Supporting further learning (10 chunks)	13. Guiding students to deep learning (7 chunks) 14. Supporting students' research (3 chunks)
Developing Student Competencies (17 chunks-16%)	Improving active learning skills (11 chunks)	15. Group discussion skills (5 chunks) 16. Peer coaching skills (3 chunks) 17. Debating skills (2 chunks) 18. Problem solving skills (1 chunk)
	Improving independent learning skills (6 chunks)	19. Information evaluation skills (3 chunks) 20. Self-directed learning skills (3 chunks)

Maintaining motivation

Maintaining motivation, with 47 chunks (44% of the whole chunks), was the most common reason for using OER. Specifically, OER was utilized to support linking to real-life applications (15 chunks), bring excitement to the session (14 chunks), support a well-planned session (9 chunks), and encourage students' engagement in the session (9 chunks).

Science teachers used OER to make real-life connections to the lesson content. T5, a Chemistry teacher, explained that when students watch animation videos about polymers, they relate every substance around them to real life. T6, a Biology teacher, confirmed that animation videos about DNA helped students imagine what is happening inside their bodies. Students became motivated and performed better when they were offered a class relevant to their real life, met their goals, and, most importantly, was related to their assignments. Teachers' utilization of OER in linking the topics with real-world examples was observed in the STEM sessions where a project-based learning approach was adopted. In this environment, students work on real projects, requiring them to search through different types of OER. Teachers believed that the strategy of letting students search and choose OER by themselves allows them some control over the content and thereby increases their motivation.

Moreover, teachers used OER to bring excitement during an 80-minute STEM session that has no break. Observations showed that visuals and animations were presented to retain students' attention and prevent sleeping during the session. T2, a Mathematics teacher, and T1, a Physics teacher, confirmed that visual media induced a sense of immersion amongst students causing more excitement than reading a reference book or viewing presentation material during the session. Teachers were observed to include a variety of OER in their syllabi to suit all students' preferences and reduce boredom levels during an 80-minute session. In nearly all cases, classroom observations showed that teachers used at least three different types of OER during the session. However, students stated the importance of a teacher's ability to choose suitable OER and utilize each type effectively in retaining their attention.

Teachers utilized OER as a method of time management during the session, as T3 noted. Classroom observations supported T3's point; teachers usually start a session with a video or other OER. Towards the middle of the session, students were asked to read some pdf references on their personal computer for a specific activity. Five teachers reported using OER primarily for brainstorming activities to help maintain students' levels of interest. Table 4 shows that, at 43%, videos were the most frequently employed OER in motivating students during the session. Most teachers selected YouTube videos to begin their sessions; educational websites followed videos at 15%. For T4, showing students a short video at the beginning of the session promoted improved understanding of new concepts while grabbing their attention. Online quizzes used as session closures were observed in T6's and T3's classrooms. T3 reported online quizzes helping structure sessions and indicate students' understanding of the topic. Also, according to T3, properly concluding the session is very important in STEM as the topics are open, and classroom discussions can confuse some students.

Some teachers used OER to challenge students. T2 and T4 reported that such OER increased student motivation, engagement, and participation. Moreover, downloading challenging questions from university websites helped stimulate their students. Teachers employed OER to support activities in the learning process by treating the hands-on activities as real learning experiences for STEM education. T2 deemed such activities were necessary for motivating students and engendering enthusiasm. Students reported YouTube videos, or simulation movies, prior to specific scientific experiences or a fab lab activity helps to understand how the experiment can be conducted or how the object is built. However, as T4 mentioned, the lack of facilities makes it difficult for teachers to provide hands-on activities such as scientific experiments. OER, such as YouTube videos, were therefore used to replace the hands-on activities.

Seeking information

The teachers identified seeking information, with 43 chunks (40%), as the second most common use of OER during STEM sessions. Specifically, OER was used to teach STEM content (33 chunks) and support further student learning (9 chunks) (see Table 3).

Each syllabus included the learning outcomes to be achieved, the concepts students will learn in each session, and the related OER. Students often had to search for additional OER to study all the concepts listed in the syllabi as the list of OER did not cover all concepts. However, T1 pointed out the difficulty in preventing students from using specific references. It was found that some OER used by the students were too advanced for the required learning outcomes. STEM education and its syllabi is open to any resources. T5 and T3 agreed with T1 and emphasized the importance of the syllabi in open STEM education environments in serving as a guide to limit students` searches for OER based on specified parameters. Students were encouraged to go beyond the materials and textbooks suggested by the teachers and to learn various STEM topics that are freely accessible to them. T5 and T6 commented that this openness encourages students to use OER, especially videos, to confirm and expand their understanding of topics studied. In this open learning environment, students were required to conduct online searching to understand the concept or the topic of the session. All teachers found this process to help students pinpoint the central concept. The teachers also agreed that when students search by themselves and identify the key concept, they do not forget the information as easily.

Teachers sometimes guide students in utilizing OER for further learning beyond what they should learn in class. T1 shared some messages from former STEM students, now university students, telling her that they are using the same references she recommended to study from during their STEM school days. Teachers also emphasized the role of OER in supporting students' research. STEM students often participate in national and international high school competitions and to prepare for those competitions they use various OER, especially academic and scientific research papers, as references for their projects. S3, a grade 12 student, commented that "without my OER computer stored digital library, I would never have been able to enter any competition and win" and complained that most of the STEM teachers lack the advanced knowledge needed to win such competitions. The teachers agreed that some pupils have a greater understanding than their teachers in some areas.

Developing student competencies

The third pedagogical purpose of using OER, measuring 17 chunks or 16% of the total chunks, was to develop students' competencies. As seen in Table 3, 11 chunks were on improving students' active learning skills while the remaining six (6) chunks were on achieving independent learning skills.

Teachers utilized OER to develop students' higher-order thinking skills, such as debating and critical thinking and to develop lower-order thinking skills such as group discussion, which are both essential for active learning. T4 explained how dividing videos into chunks enhanced students' thinking skills during group discussion. Showing a short segment of the video prior to discussion helped students develop a better understanding of a discussion topic step-by-step so building confidence to discuss the topic, in full, with their team members. Three teachers reported using OER to enhance students' peer coaching skills. T1 reported that some of the students used MOOCs or other OER and explained the content to fellow students. T5 mentioned that sometimes students explained a new topic of which the teachers were unaware. T6 used debate activities to develop and utilize students' analytical and critical thinking skills.

Students reported what they have learned from pdf materials and presented and defended their opinions. It was noted that they understood that locating OER which contained good content and were written logically is the key to improving their debating skills. T4 reported that problem-solving skills were acquired while using OER, in which students were tasked with solving real-life problems. Students also reported using all OER available to understand the problem before taking systematic steps towards solving it.

Teachers also used OER to enhance students' independent learning skills, allowing them to take control of their learning process and assume responsibility for their learning. The OER also aided in developing students' confidence which, in turn, increased learning success. T1 stated the freedom given to students in selecting their resources helps develop information evaluation skills in assessing whether certain resources enhance their performance. As the students have to decide which materials are more beneficial, they went through a lot of materials thus acquiring evaluating skills which helped them assess the quality and usefulness of materials. As T3 and T6 commented, while selecting their own resources, students also developed "self-directed learning skills," which they applied to new learning. S1 said, "I learned about this note-taking strategy when watching a video. It was very helpful for me, and I advised my friends to use it. I then explained it to my teacher, he found it interesting and now uses it in our class. I am happy because he always mentions my name when he applies this strategy". S9 added that a teacher's encouragement and praise boosted her confidence.

Types of OER used for each pedagogical purpose

Teachers reported using certain OER more often than others in accordance with pedagogical purposes (see Table 4).

Videos were the most frequently utilized OER to maintain student motivation. Research papers and online quizzes were the least effective in bringing interest and enjoyment to students as they demanded more effort and time, causing stress and anxiety in students.

Pdf references were the most frequently used OER to provide information and course content; the reason was that instead of adopting hardcopy textbooks, the school used online textbooks as its main instructional materials. T1 stated, "If you ask me to describe what STEM is, I will say it is an open education system. For students to learn and for us to teach, OER is our STEM textbooks".

Reading materials were the most common OER used to develop student competencies. Teachers reported reading pdf references improved low-order thinking skills, such as group discussion, and high-order thinking skills, such as critical thinking. T3 explained that students comprehend the information better when read as texts as it stimulates their thinking, allowing them to present their understanding logically. S7 reported, "Reading materials in English helped me improve my thinking strategies. I can easily express my ideas in Arabic but am not used to defending my opinion in English. The more I read texts in English, the more I learn how ideas are presented in English".

Table 4

Types of OER Used inside STEM Sessions according to Each Pedagogical Purpose

Types of OER	Maintaining Motivation	Seeking Information	Developing Student Competencies
pdf references (online textbooks)	3 chunks (6%)	18 chunks (42%)	5 chunks (29%)
Videos	20 chunks (43%)	6 chunks (14%)	3 chunks (18%)
Online quizzes	3 chunks (6%)	0 chunks (0%)	1 chunk (6%)
Educational websites	7 chunks (15%)	6 chunks (14%)	4 chunks (23.5%)
Research papers	2 chunks (4%)	2 chunks (5%)	0 chunk (0%)
Other	12 chunks (26%)	11 chunks (25%)	4 chunks (23.5%)
Total	**47 chunks (100%)**	**43 chunks (100%)**	**17 chunks (100%)**

Discussion

OER for content learning and teacher training

Previous studies in advanced countries (Jhangiani et al., 2016; Jung & Hong, 2016; Jung et al., 2016) reported OER being frequently used as supplementary resources, mostly to promote student motivation and improve teaching effectiveness in higher education. Contrastingly, this case study, conducted in a STEM high school in a less advanced country, found OER to be used as the main resource for teaching and learning. The school, not having a fixed curriculum with any formal textbooks, required the students and teachers to use OER as their textbooks, not just to promote motivation, but also to study new content and develop learner skills necessary for inquiry-based STEM learning. This highlights the importance of selecting high-quality OER, especially in a context where OER replaces traditional textbooks and is used as the main source for content learning. As noted in several studies (Erdogan & Stuessy, 2015; Peters-Burton et al., 2014; Shernoff et al., 2017), appropriate and continuous professional development is a necessity for STEM teachers to discover, create, adapt, revise, and manage high-quality OER that are both relevant and effective in achieving desired outcomes in STEM learning.

An argument can be made that schools must provide training and update teachers on selecting relevant, high-quality OER and adapting them for their students. However, considering the lack of resources for STEM schools, in less advanced countries, to offer professional development, one feasible solution appears to be the utilization of several freely available OER training modules, developed by various organizations such as UNESCO, OER Africa, OpenStax, Open Education Consortium, and others, as self-training materials, followed by peer tutoring and support sessions.

OER for student motivation

Teachers use OER for maintaining student motivation, and this is consistent with previous studies explaining how OER motivates students and keeps their attention in diverse educational settings (Jung & Hong, 2016; Kew et al., 2018). Motivation is what learners want to achieve or desire, and it decides the direction and the magnitude of student behavior towards learning (Keller, 2010).

Keller's ARCS model is of a motivational design helping teachers identify problems with student motivation and design strategies which can be used to make instruction match the interests and needs of students in the four categories of ARCS. Each of these categories suggests sub-categories of motivational strategies to incorporate into instructions, as shown in Table 5.

When applying the ARCS framework to the nine codes under the category of maintaining motivation seen in Table 3, it can be seen that seven codes are related to Attention, as shown in Table 5 below. The teachers observed tend to apply a wide range of strategies when using OER, mostly to gain students' attention. While the teachers promote inquiry arousal by engaging students in such activities as brainstorming, project-based learning, and addressing learning challenges with OER, they do not apply two other important attention strategies for effective inquiry-based learning in STEM education, namely, "questioning" and "hypothesis generating" as also indicated in Pedaste et al. (2015). This may be explained by the lack of teacher competencies in effective OER use or the lack of teachers' understanding of inquiry-based pedagogies (Fitzgerald et al., 2019).

Table 5

Assignment of ARCS Categories and Sub-categories into Codes Emerged from the Study

ARCS Model Categories and Sub-categories		Codes Emerged from the Study
Attention	Perceptual Arousal	1. Real-life connection 3. Visual media attention
	Inquiry Arousal	2. Project-based learning 6. Brainstorming 8. Challenges 9. Activities
	Variability	4. Varieties
Relevance	Goal Orientation Motive Matching Familiarity	N/A
Confidence	Learning Requirement	5. Time management 7. Session closure
	Success Opportunities Personal Control	N/A
Satisfaction	Intrinsic Reinforcement External Reward Equity	N/A

Another important observation from Table 5 is that the teachers did not use strategies to promote relevance and satisfaction when utilizing OER. This observation explains why teachers encounter difficulties modifying and producing OER on their own to meet the demands and expectations of their students in the future. According to El Nagdi and Roehrig (2020), most teachers attribute their lack of knowledge and skill in using technology and generating OER to a lack of professional development opportunities.

Confidence is linked to time management and session closure since they teach students about the learning requirements for each session. According to the teachers, students pay more attention when the session time is carefully organized and follow a regulation class plan that incorporates OER in innovative ways. This finding aligns with Mega et al. (2014), who argue the positive effects of time management on self-regulated learning, motivation, and learning outcomes.

OER for building student competencies

Inquiry-based STEM learning focuses on engaging students in the learning process and applying the knowledge learned to real-world problems. Students also need to build competencies for successful STEM learning, such as active and independent learning skills. The present study reveals that OER is used not only for gaining and maintaining student motivation along with teaching new concepts but also for developing some student competencies required for successful STEM learning. Its findings are consistent with a recent study conducted by Rahayu and Sapriati (2018) that states students' critical thinking skills are further developed using OER. These competencies are critical for equipping students with the knowledge, skills, and attitudes needed to learn beyond graduation from STEM schools successfully.

The OECD Learning Framework for 2030 states that any type of education needs to equip students with skills and competencies to become active, responsible and engaged citizens and identifies a broad range of cognitive, and meta-cognitive skills such as critical thinking, creative thinking, problem-solving, learning to learn and self-regulation (OECD 2018). The present study's findings show how students are gaining various competencies while integrating OER as part of their learning process and categorically suggest that OER use effectively supports the OECD Framework and equips STEM students with 21st-century competencies.

Conclusion

STEM teachers were found to be integrating pdf references, videos, educational websites, and online quizzes as OER throughout the STEM teaching and learning process. The study identified three pedagogical purposes of OER use in the context of STEM education in a less advanced country: 1) maintaining motivation, 2) seeking information, and 3) developing student competencies. Teachers reported using certain OER more often than others in accordance with pedagogical purposes. Videos were the most frequently utilized OER to maintain student motivation. Pdf references were the most frequently used OER to provide information and course content. Reading materials were the most common OER used to develop student competencies. Findings also showed that the integration of OER in STEM education promotes student engagement and provides students with the opportunity to open their minds, widen their visions, and explore the outside. Therefore, a strong argument can be put forward that OER has a positive influence in motivating, teaching new content, and developing 21st-century competencies for STEM school students in Egypt and other developing nations.

The study contributed to the limited literature on using open educational practice applications such as OER in K-12 education (Tlili et al., 2021). Findings of this case study question if having textbooks is essential for student learning and whether OER can substitute them in the future. The role of textbooks is to deliver specific knowledge through the medium of text where students can learn directly from what they are reading with a limited analysis process. By providing preselected content, textbooks set an agenda and guide students' minds to what they will learn. Conversely, they tend to limit the students' intellectual curiosity and inquiring mind. OER, offered in different modes and types, may have a better potential to meet the different learning needs and styles of students and even improve their ability to learn (Davy, 2007; Grasha & Yangarber-Hicks, 2000). Having stated this, the argument needs to be confirmed empirically in future studies.

Some limitations of the study need to be pointed out with a view towards future research. The study was conducted at only one STEM school in Egypt. It would be desirable to consider the effect of varied geographical locations and investigate more than one school. Also, data were collected and reported across different STEM subjects. It would be interesting to analyze the results according to each subject separately and possibly identify different methods of utilizing OER across varied STEM areas.

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Online Learners' Exposure to Natural Hazards Risks in the Philippines: Implications for Student Support and Policy

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Abstract

Climate-related disasters have been projected to intensify in the coming years. Academic institutions have looked at online learning as the disaster-resilient response for education. However, online learners remain exposed to the risks of natural disasters. Schools and universities should develop a student support system that is responsive to the needs of learners in areas with high disaster risk. There is a need to analyze the distribution of online learners in these areas and determine the student support implications of the pattern as initial steps towards developing such a system. With this, the current study analyzed the exposure of online learners of an open and distance e-learning (ODeL) university to risks of natural hazards in the Philippines. The profile of learners (n = 3,225) enrolled during the first trimester and the first semester of the Academic Year 2020–2021 and the disaster risk maps developed by the Center for Environmental Geomatics, Manila Observatory were entered into a GIS environment and analyzed. Results indicated that more than 80% of the learners are in regions with high to very high risks to climate-related hazards. Less than 10% is within areas with high risks to earthquakes. This is critical since climate disturbances in the country are recurrent and destructive, causing the loss of life and property, power outages, and internet service interruptions for weeks or months. Online learning institutions should develop a student support system that could assist their learners in overcoming the impacts of a disaster on their academic life.

Keywords: *online learning, disaster resilience, disaster risks, geographic information system, natural hazards*

Introduction

Projections of the climate change scenarios are dim in the coming years for developing countries such as the Philippines. Cinco et al. (2018) projected that the country would experience continuous warming in the future and the frequency of strong typhoons and extreme rainfall events will increase. This is critical since the country must still overcome the current pandemic's paralyzing effects on its economy and other public services including education. The education sector has integrated remote teaching and learning (RTL) as part of its operation continuity plan during the pandemic. Although it has faced several technological, pedagogical, and social challenges, many if not all academic institutions in the country and throughout the globe have adopted RTL to continue delivering education to their students (Ferri et al., 2020). In most instances, the adoption of online learning has been at the forefront of the fight against the impacts of the pandemic on education. Although Hodges et al. (2020) indicated that its adoption had prompted experts, policymakers, citizens, teachers, and learners to search for new solutions, online learning has attracted more and more institutions worldwide. In fact, Li and Lalani (2020) had reported that the overall market for online education can reach up to US$350 billion by the end of 2025 from US$18.66 billion in 2019 with the sudden shift of education away from the conventional face-to-face modality.

But while it becomes a highly utilized modality during the pandemic, online learning could be at risk with various disasters. Its dependence on the internet and power supply makes it highly vulnerable to the intensifying impacts of climate change. In countries like the Philippines, where power supply and telecommunication facilities are severely affected by disasters (Rudnick, 2011), online learning institutions should develop a disaster preparedness program that could support their teaching and learning continuity plan while enhancing their teacher's and learners' academic restoration, recovery, and rehabilitation capabilities. While the program is highly imperative (Tkachuck et al., 2018), it has received little attention from online learning-providing institutions. Collecting online learners' geographic data, analyzing their distribution in areas with high vulnerability to natural disasters, and determining the student support implications of the pattern are initial steps towards developing such a program, hence, the study.

The study aimed to: (a) analyze the learners' exposure of online learners to risks of natural hazards in the Philippines; and (b) determine its student support and policy implications. The analysis has been facilitated using a geographic information system (GIS). GIS is a valuable tool for spatial pattern analysis studies with categorical data for decision-making (Franch-Pardo et al., 2020).

Review of Related Literature

The Philippines is ranked as the fourth most at-risk country globally to climate-related natural disasters such as typhoons, flooding, and extreme temperature (Alcayna et al., 2016). These hydrometeorological events accounted for 80% of the natural disasters in the country (Jha et al., 2018). The Philippines is also among the world's top three countries with the largest population exposed to natural disasters (United Nations Office for Disaster Risk Reduction [UNDRR], 2015a). Furthermore, Anttila-Hughes and Hsiang (2013) reported that average losses in the country remain high even in highly adaptive regions due to increases in average population exposure to wind speed during a typhoon. In fact, in 16 years, about 23,000 people died, and roughly 125 million were affected by natural disasters between 2000 and 2016 (Jha et al., 2018).

The recurrence of disasters in the Philippines can compromise the effectiveness of online learning as a mode of teaching and learning. The increasing frequency of strong typhoons and extreme floods in the country can negatively affect several critical infrastructures such as electricity and internet towers that support online learning. Aside from being destroyed, these facilities may not be able to withstand the increased stress during post-disaster usage, and consequently, may fail to accommodate the increasing demands of the affected communities (Choi et al., 2016). For instance, the power supply in affected communities may be rationed by electric cooperatives to avoid operation disruption of the remaining plants after a disaster. Internet service providers may even discontinue their services to allow rehabilitation of their affected infrastructures.

These and other post-disaster rehabilitation activities for the facilities will significantly impact learners' access to learning activities and participation in peer interactions and discussion forums in online education. Power and internet service interruptions can negatively affect the performance of learners in their studies. According to Bisharyan (2021), online learners in the United States have fallen behind on schoolwork because of power outages and unstable internet connections. The condition was acute for underprivileged learners who did not have access to a stable internet connection (Bisharyan, 2021). Walravens (2020) reported that power outages due to disasters during online education had marginalized the underprivileged learners. Delos Reyes (2021) reported a similar situation in the Philippines, where rotational power outages after a typhoon or other natural disasters have complicated the challenges that poor internet connection creates among rural learners. These learners are unable to fully participate in their online classes that are either synchronously or asynchronously conducted. Alam (2020) and Bao (2020) had indicated the impact of inadequate participation in the teaching-learning process on the mental health of online learners. They reported that learners had developed a negative perception of online learning, which might increase their psychological distress. Such psychological distress has been complicated by the fear of losing an academic year. Hasan and Bao (2020) also stated that fear of academic year loss enhanced learners' psychological anxiety.

These impacts highlight the importance of making online education resilient to disasters. Though the need for resilient online learning is glaring, its development has received little attention from education managers and academic institutions worldwide. However, academic continuity is necessary since education is considered a key driver for sustainability. The UN Sustainable Development Goal (SDGs) emphasized that quality education promotes core societal values, including sustainable lifestyles, respect for human rights and diversity, and culture of peace and non-violence (Bartusevičienė et al., 2021). According to Bartusevičienė et al. (2021), online learning providers must continue to deliver uninterrupted quality education through adaptations and adjustments to their learners even during a disaster.

Methodology

The study was conducted following a descriptive design approach where data were processed and analyzed using a geographic information system. Means and percentages were computed, and there has been no attempt to do any inferential statistics with the data.

The total enrollment data (n = 3,225) during the First Semester and First Trimester of the Academic Year 2020–2021 was used in the study. Students' data on geographic location were retrieved from the Office of the University Registrar's (OUR) database in an online learning university in the Philippines. Geographic location refers to the students' municipality or city of residence. The total number of students per geographic location was requested from the OUR and used as the value for each geographic ID, which was named following the official political name of the municipality or city in the GIS-enabled map. The resulting map was then labeled the "Student Distribution" map.

Likewise, the level of risk was determined using the qualitative description used by the Center for Environmental Geomatics, Manila Observatory, as reflected in their natural disasters' vulnerability maps for the entire country. The maps were downloaded from their website, http://vm.observatory.ph, as open access. Since these were jpeg maps showing the level of vulnerability of each municipality to natural disasters, they were converted into vector maps in the GIS. The attributes tables for these maps were populated with the levels of risks to the three commonly occurring hazards in the country, namely, typhoons, extreme rainfall, and earthquakes. However, a combination of the climate-related risks was also considered in the analysis. There were five (5) levels of vulnerability used in the study, namely, very high, high, medium, low, and very low, which corresponds to the levels of risk to natural disasters computed for each of the municipalities. The resulting maps were labeled "Vulnerability Maps."

Data Privacy and Confidentiality

To address data privacy, only aggregated data per geographic location were collected and reflected in the analysis and discussion of the results. Permission from the OUR was also secured to use such a data set.

Data Analysis and Visualization

The students' vulnerability level to natural disasters was determined and analyzed using the GIS software's georeferencing extension. The maps for the student distribution and vulnerability were intersected. The resulting map was re-coded to reflect the number of students across vulnerability levels on each polygon. The percentage of the students in each vulnerability level was then computed. Data were visualized as tables and maps.

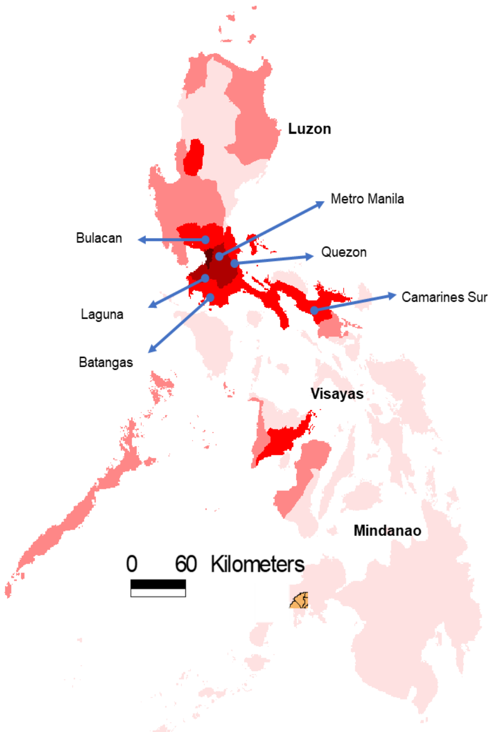
Results and Discussion

Spatial Distribution of Students

Students enrolled during the first semester and first trimester AY 2020-2021 were highly concentrated (n = 3,062, 85%) in the Metropolitan Manila areas and the municipalities and cities of Laguna, Bulacan, Batangas, and Quezon though some were in Camarines Sur and Iloilo (Figure 1). This is critical since most of these places are highly vulnerable to climate-related natural disasters such as flash floods, typhoons, extreme rainfall, and landslides or mudslides.

Figure 1

Spatial distribution of students

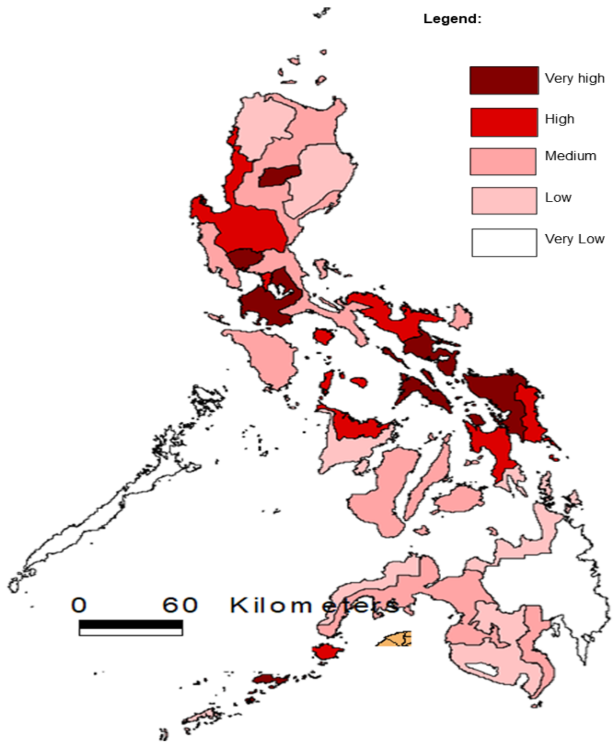


Note. Base map adapted from Manila Observatory-Center for Environmental Geomatics, 2005; Student data were retrieved from the OUR database with permission.

For instance, Marikina City, which is located along the eastern border of Metro Manila, suffered from a severe flood event on November 12, 2020, due to Typhoon Ulysses (Marquez, 2020). In 2009, the Metro Manila area had been affected by a flood due to Typhoon Ondoy. The flood had caused more than 200 fatalities and affected almost a million people throughout the metropolitan areas (Sato & Nakasu, 2011). Moreover, the provinces of Laguna, Quezon, and Batangas had suffered significantly from the impacts of Typhoon Glenda in 2014. According to Francisco (2014), the typhoon had toppled down trees and powerlines, resulting in widespread blackouts in these areas. The recurrence of these disasters highlights the need to develop strategies that can make online learning more adaptive and resilient to the impacts of these disasters. This is necessary because the computed risks to climate-related disasters for these areas are high to very high (Manila Observatory-Center for Environmental Geomatics, 2005), as indicated in Figure 2. Areas with high or very high risks to disasters have a higher likelihood that lives would be lost, and properties and infrastructures would be damaged (UNDRR, 2015b).

Figure 2

Combined Risks to Climate Disasters



Note. Base map adapted from Manila Observatory-Center for Environmental Geomatics (2005). Student data were retrieved from the OUR database with permission.

Meanwhile, students from the Visayas region (n = 132) constituted only 4% of the total enrollment while students from the Mindanao region have recorded no enrollment during this term. However, it must be emphasized that the data utilized in this study came from the enrollment report for the first trimester and first semester AY 2020-2021 only. The university may have students based in the Visayas and Mindanao regions but was unable to register during this term. Hence, it is recommended that a study involving enrollment data in various terms and academic years be conducted to widen the temporal scope of the analysis. Moreover, it is possible that similar student support and policy implications can be derived from the analysis.

Exposure of Students to Rainfall Change Risks

The intersection of the student distribution and vulnerability maps revealed that about 80% of the total number of students enrolled during the period of the analysis is residing in areas with high to very high risks to changes in rainfall patterns (Table 1).

Table 1

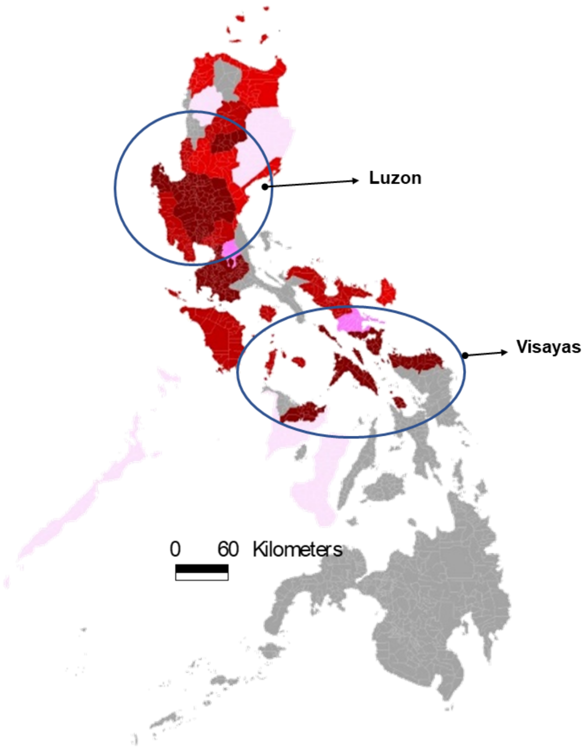
Percent distribution of students by level of risk to rainfall change

Level of Risk	Total Number	Percent
Very High	2,290	71
High	290	9
Medium	194	6
Low	193	6
Very Low	258	8
Total	3,225	100

As indicated in Figure 3, these students are distributed in the Luzon and Visayas regions specifically in the municipalities of Ifugao, Tarlac, Pampanga, Metro Manila, Cavite, Laguna, Batangas, Rizal, Quezon, Northern Samar, Masbate, and Capiz. These students are highly vulnerable to the impacts of flash floods and landslides as consequences of the changing rainfall patterns (Marengo et al., 2021). These consequences can be catastrophic and detrimental to the students' academic performances, especially when the infrastructures that support online learning are damaged during the occurrences. Guzzetti et al. (2012) indicated that landslides could result in massive loss of life and destruction of infrastructure and housing. Kocaman et al. (2020) cited similar impacts and reported that flash floods and landslides could cause loss of many lives, displacement of people, and collapse of critical infrastructures such as power lines, hospitals, water supply, and large construction. Power outages and internet disconnections due to these disasters can create significant academic impacts on online learning, given that such a modality is greatly dependent on these facilities.

Figure 3

Risks to Rainfall Change



Note. Base map adapted from Manila Observatory-Center for Environmental Geomatics (2005). Student data were retrieved from the OUR database with permission.

In a study by Rotas and Cahapay (2020) on the difficulties in remote learning due to the pandemic, power interruptions and unstable internet connections were among the factors identified that affected students' learning motivation and performance in an online learning modality. Ragobeer (2020) also pointed out that internet disconnection can create fear among online learners, leading to stress and anxiety. On the other hand, Campbell (n.d., as cited in Ragobeer, 2020) argued that power outages could be more stressful to students because of the uncertainty of when the power will be restored. The presence of stress and anxiety among online learners is critical because these can affect their cognition, physiology, and behavior (Huberty, 2009), which can significantly affect their academic performance (Ajmal & Ahmad, 2019).

Exposure of Students to Risks of Typhoons

Although only 4% of the total enrollees during the period of analysis were in areas with very high risk to typhoons, about 83% were within places with high risk to such a hazard (Table 2).

Table 2

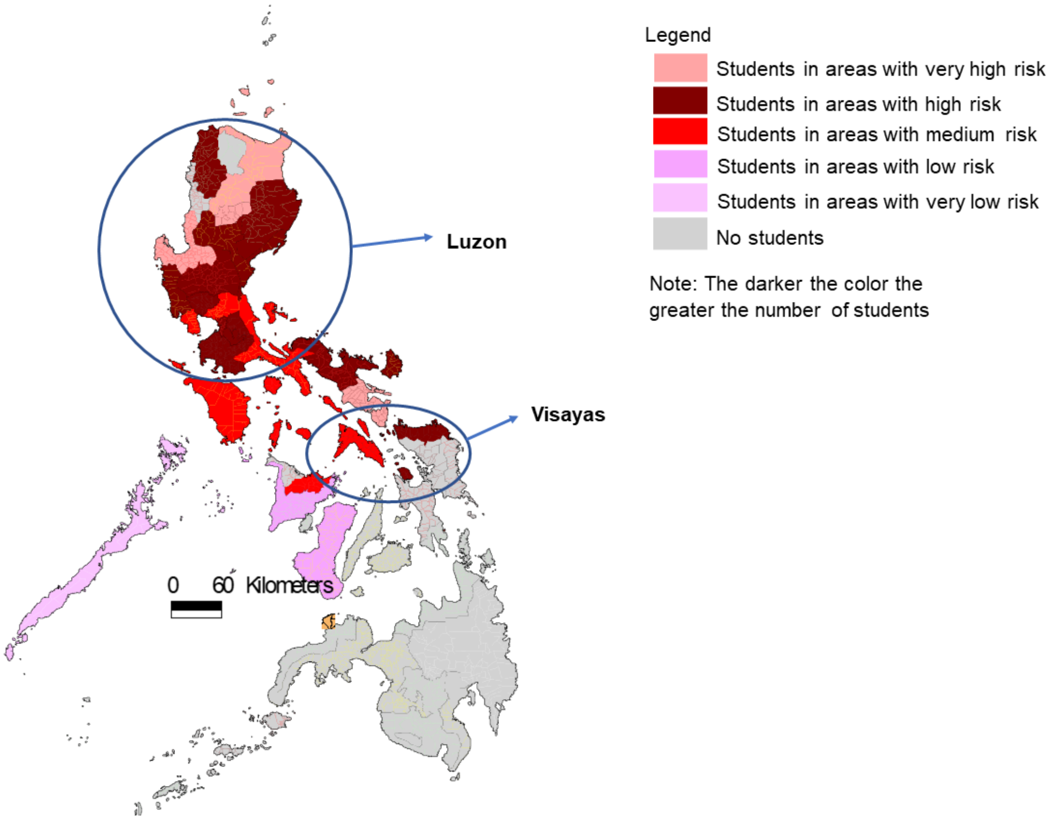
Percent distribution of students by level of risk to typhoons (n = 3,225)

Level of Risk	Total Number	Percent
Very High	129	4
High	2,677	83
Medium	258	8
Low	129	4
Very Low	32	1
Total	3,225	100

As with the change in rainfall patterns, students in Luzon especially those living in Ilocos Norte, Abra, Ifugao, Pampanga, Metro Manila, Quezon, Laguna, Batangas, Bataan, Zambales, Pangasinan, Benguet, Bulacan, Camarines Norte, Camarines Sur, and the Bicol region as well as students in the Visayas provinces (e.g., Northern Samar and Biliran) are highly vulnerable to typhoons (Figure 4). Specifically, as indicated in Figure 4, most of the students who are vulnerable to typhoons during the period of analysis are in Luzon. But this pattern may change, especially when more and more students from the Visayas and Mindanao islands will be re-enrolling in the succeeding academic years.

Figure 4

Student distribution by level of risk to typhoons



Note. Base map adapted from Manila Observatory-Center for Environmental Geomatics (2005). Student data were retrieved from the OUR database with permission.

Nonetheless, this situation can be considered a "double disaster" (Cueto & Agaton, 2021) for these students considering that Luzon has also been the center of the recent pandemic. There have been studies (e.g., Ku, 2020; Cueto & Agaton, 2021) indicating the increasing impacts of this state of "double disaster" on the mental wellness of online learners. For instance, Ku (2020) reported that the impacts of Super Typhoon Rolly that hit the country in November 2020 had negatively affected the mental health of online students in the Bicol region. Online students were stressed and depressed because they failed to participate in their online interactions, access their learning materials, and submit their assignments and outputs of the learning activities. After the typhoon, the power supply outage and the intermittent internet and mobile signal in the region disrupted students' access to their virtual classrooms (Ku, 2020).

In addition, Cueton and Agaton (2021) reported that the occurrence of natural disasters during the lockdown from pandemic in the country had brought stress to students, especially those who need to be relocated to evacuation centers. Students expressed their anxieties about failing to complete their requirements and access their online learning, aside from their worries of being infected by the COVID-19 virus within the evacuation facilities (Cueton & Agaton, 2021). Thus, the concentration of students in areas with high to very high risks to typhoons highlighted the need to provide mental wellness support to students to minimize both disaster-related and academic-related stresses and depression.

Exposure of Students to Earthquake Risks

Unlike the trends in the first two hazards, the spatial analysis of the data indicates that only a few students who were enrolled within the period of analysis are exposed to medium to high risks in terms of earthquakes. To cite, about 9% (n = 290) of the total enrolled students included in the study are in areas with high risks to the earthquake, while more than 60% of the students (i.e., 65%, n = 2,097) are in areas with medium risks to an earthquake. Specifically, these students are distributed in areas like Metro Manila and its nearby provinces of Cavite, Batangas, Bulacan, Aurora, and Rizal and the provinces of Bicol and Eastern Visayas regions (Figure 5). These areas have existing active fault lines, which may move anytime and cause significant damage including toppling down of critical infrastructures such as power lines and internet towers. Both facilities are important in the delivery and access of online learning courses. For instance, Pacific Consultants International (2004) conducted an earthquake damage analysis for Metro Manila and nearby areas that indicated a gloomy scenario for these areas. According to their analysis, the Metropolitan Manila areas will possibly be separated into four regions because of the impacts of the earthquake. These impacts include a collapse of buildings, immobility due to the collapse of major bridges and flyovers, cutting of communication and power lines, and interruption of water supplies. Likewise, the earthquake that jolted the Eastern Visayas region in 2017 had triggered power interruptions in the affected areas such as Tacloban and Ormoc City (Bartolome, 2017).

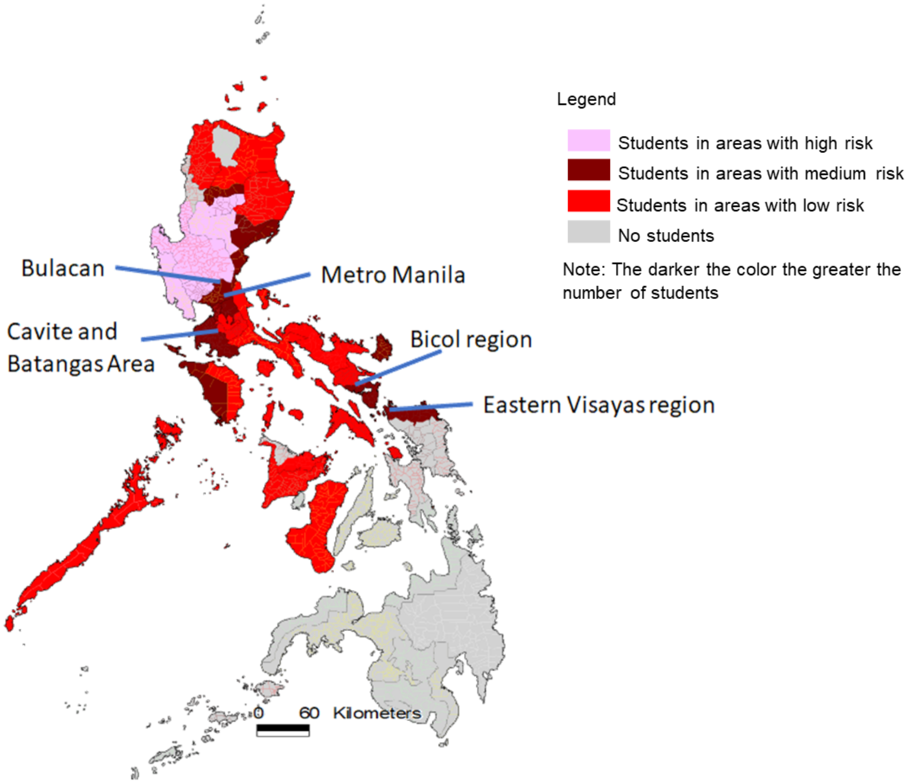
Thus, it is important to consider how to manage the impacts of this hazard in the teaching-learning continuity plan of the University.

Implications for Student Support and Policy

The occurrence of climate-related hazards such as typhoons and floods, as well as geologic-related hazards such as earthquakes and landslides, should be an important consideration in an online learning environment. Though all teaching and learning transactions in this modality may take place in a virtual environment, online learning is highly vulnerable to power outages and internet service disruption during a disaster. Thus, it is imperative for online learning institutions to create and establish a student support system that allows continuity of the teaching-learning process. The creation of this system should be supported with policies.

Figure 5

Spatial distribution of students by level of risks to earthquake



Note. Base map adapted from Manila Observatory-Center for Environmental Geomatics (2005). Student data were retrieved from the OUR database with permission.

In the current study, it is observed that most of the learners are distributed in areas with high to very high risks to climate-related hazards such as typhoons, changes in rainfall patterns, and floods. Such spatial distribution pattern implies that most students could be disconnected from their virtual classes whenever these hazards occur in their area. A student support system that provides an offline learning experience for these students is necessary. It means that the learning materials, activities, and/or interactions should have offline equivalents to allow these students to continue their learning process amidst disruption in power or internet services. For instance, learning materials can be in downloadable formats so that students can download and use them even if they are not connected to the internet. A policy that supports free downloading, using, and storing of materials outside of their original online repository sites should be formulated so that students can be legally protected from any copyright infringement issues. However, such a policy should provide the limitations on the distribution and reproduction of materials to protect the copyright of the authors or institution over them unless they are published as open educational resources.

Likewise, the institution should also invest in a learning management system with an offline feature or one that supports offline access to the course contents. Such a learning management system feature allows students to engage in self-paced offline learning according to their learning conditions after a disaster (Paradiso, n.d.). Allowing the learning process to continue even in an offline mode may reduce students' anxiety from being disconnected from their classes. As Ragobeer (2020) reported, students have developed anxiety when disconnected from their online classes due to internet service interruption. Thus, the offline feature of a learning management system can help address this concern (Paradiso, n.d.).

In addition, a student support system should ensure flexibility in the teaching-learning process. Such flexibility could range from extending the deadlines of submission of course requirements to having diverse assessment tools. Diversifying the assessment approaches to learning does not only address the impacts of disasters on the teaching-learning process but also ensures the appropriateness of a tool on the current learning environment of the students after a disaster. It should also provide an enabling environment to the faculties-in-charge to identify, develop, and implement such a variety of tools.

The vulnerability of students to both climate and geologic-related disasters necessitates that the online learning-providing institutions establish a student support system that addresses the impacts of disasters on students' mental health. According to Makwana (2019), disasters can result in the mental instability of the victims, which might precipitate Post Traumatic Stress Disorder, anxiety, and depression. These disorders may affect the learning process of the students (Bisson, 2017), which may lead them to disengage from their classes. To minimize, if not eliminate the desire to drop out from their courses after a disaster, the student support system should be able to assist and connect students to available resources that will sustain them in their path of success (Bisson, 2017). A policy that allows such assistance and connection should be formulated by and implemented in the institution.

Conclusion

There is an increasing demand for online learning, especially with the uncertainty of the current pandemic. However, the high dependence of online learning on the availability of power and internet services makes it highly vulnerable to the impacts of disasters. Because the Philippines is a disaster-prone country, it is important to analyze the spatial distribution of online learners in the country to the risks of such natural hazards as typhoons, floods, extreme changes in rainfall patterns, and earthquakes. The use of GIS has facilitated this analysis in the current study.

Results have indicated that most online learners enrolled during the First Semester and First Trimester of the academic year 2020–2021 in an open and distance e-learning university in the Philippines are distributed in areas with high to very high risks to climate-related hazards such as typhoons and floods. However, this spatial pattern may change if the university's total student population is included in the analysis and a more recent geospatial distribution of risks to natural hazards in the country will be used in the GIS analysis.

Nonetheless, the current pattern has significant implications for student support and policy formulation. The concentration of students in areas with high to very high risks to climate-related hazards necessitates the creation of a student support system that allows self-paced offline learning either as an important feature of the learning management system of the university or an integral part of its course delivery and management system. For instance, such a support system should allow students to download, use, and save their learning materials outside of their original repository site. The student support system should also ensure flexibility in the teaching-learning process and address the impacts of disasters on students' mental health. The provision of assistance and connection to available resources that could help students overcome their depression and anxiety due to the disaster must be an important feature of the student support system. All processes and activities of this support system should be backed up with policies.

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We call on colleagues, such as academics, researchers, technology developers, and open distance e-learning experts to submit their articles for publication in the International Journal on Open and Distance e-Learning. The IJODeL is a bi-annual journal, hence it comes out every June and December of the year.

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Template for Quantitatively-Oriented Articles

Title of Article

Author 1[1]and Author 2[2]

[1]Position, Institutional Affiliation, Country, Email address

Abstract

Abstract in 150-250 words.

Keywords: No more than five (5) keywords.

Introduction (Center Heading 1)

This section contains a clear historical background of the study, showing why the research had to be undertaken. In this section, the author(s) shall have the opportunity to expound on what the research says about the research problem, and show clear support for the need to undertake the research, through appropriate research gap analysis.

Objectives (Center Heading 2)

This section provides a clear statement of the goals and objectives of the research.

Conceptual/Theoretical Framework (Center Heading 3)

The conceptual or theoretical framework would be expected for research studies that dealt with empirical procedures and methodologies. A framework of this nature would provide for clear interrelationships and direction of interactions of variables which the researcher expects to show by his/her data and data interpretations. It should be noted that variable interactions may be easier to understand if they were to be presented in illustrated model formats.

Methodology (Center Heading 4)

This section includes brief discussions of data collection procedures and analyses. Data must be presented in appropriate tables.

Results and Discussions (Center Heading 5)

Analytical discussions must present possible relationships of the results of the study and the findings from other studies specifically reviewed for this purpose. Post analysis data may be presented in both statistical tables and appropriate models and figures.

Include subheadings as are necessary.

Conclusions and Recommendations (Center Heading 6)

Conclusions must be according to the objectives of the study.

Recommendations must reflect the objectives and conclusions of the study.

References

General format must follow the suggestions for authors, but generally must follow the APA Style for publications.

Template for Qualitatively-Oriented Articles

Title of Article

Author 1[1] and Author 2[2]

[1]Position, Institutional Affiliation, Country, Email address

Abstract

Abstract in 150-250 words.

Keywords: no more than five (5) keywords

Introduction (Center Heading 1)

This section contains the historical background of the study, including specific reports and studies that provided direct support to the research problem. Some relevant part of the literature shall be included in the discussion of the research problem to establish more strongly the need to undertake the study.

Objectives of the Study (Center Heading 2)

This section contains both the research over-all goal and the specific objectives to be attained.

Relevant Studies or Review of Related Studies (Center Heading 3)

Review of studies that are highly related to the current study. After the relevant studies have been presented, a synthesis of these may be presented and the relationship of such synthesis must be related to the study under consideration.

Subheading may be determined as necessary. In these subheadings, specific observations may be noted and statistical tables presented as well as figures and models.

Discussions (Center Heading 4)

In this section shall be inserted full discussion of results and finding, discussed more deeply in relation to the related studies already reviewed. Subheads may be determined and included in the discussions.

Conclusions (Center Heading 5)

The conclusions of the study must reflect the objectives of the research.

Recommendations (Center Heading 6)

All recommendations must appropriately correspond to the conclusions, and therefore the objectives of the study.

References (Center Heading 7)

Follow the APA Style Guide.

Style Guide for Full Paper Submission

The paper should be 15-25 pages long (including tables, figures, and references) and prepared preferably in Microsoft Word format. The author(s) should provide a title, the name(s) of the author(s), position(s), institutional affiliation(s), institutional address(es), email address(es) and key words (no more than five). You may make use of the template for preparing your paper: Journal Article Template (Qualitatively-Oriented); Journal Article Template (Quantitatively-Oriented). Detailed guidelines are as follows:

1. **Font type**
   The whole text should be in Arial.

2. **Margins**
   The paper should be A4 size (21 x 29.7 cm). All margins (top, bottom, left, and right) should be 1 inch.

3. **Line Spacing**
   The whole text should be single-spaced.

4. **Title**
   The title of the paper should be 14-point, bold, in capital and lower case letters, and centered.

5. **Author Information**
   Use 12-point and centered for the author name(s). The Western naming convention, with given names preceding surnames, should be used.

   The author name(s) should appear below the title, with one blank line after the title.

   Use 10-point for author(s)' position(s), institutional affiliation(s), country, and email address(es).

   The author(s)' position(s), institutional affiliation(s), institutional address(es), and email address(es) should appear below the author name(s), with one blank line after the name(s).

6. **Headings**
   - Heading font (with the exception of the paper title and the abstract) should be 14-point Arial and in bold.
   - Headings should be centered and in capital and lower case letters [i.e. nouns, verbs, and all other words (except articles, prepositions, and conjunctions) should be set with an initial capital].
   - There should be two blank lines before each heading and one blank line after it.

7. **Subthemes**
   - Subtheme(s) should be 14-point Arial, in bold capital and lower case letters, and flushed left.

- There should be one blank line before and after each subtheme.

8. **Abstract**
   - The abstract heading should be 14-point Arial, bold, centered.
   - The abstract should be in 150-250 words.
   - The main text of the abstract should be 12-point Arial, italicized.
   - Alignment of the main text of the abstract should be justified, no indent.

9. **Key Words**
   - Include at most five keywords.
   - Use 12-point Arial. The keywords should appear below the abstract, with one blank line after the abstract.

10. **Main Text**
    - In general, paragraphs should be separated by a single space.
    - All paragraphs must be in block format.
    - Text font should be 14-point Arial, single-spacing. Italic type may be used to emphasize words in running text. Bold type and underlining should be avoided.
    - The first line of each paragraph should not be indented.

11. **Tables and Figures**
    - Tables and figures should be numbered and have captions which appear above them.
    - Graphics and pictures should not exceed the given page margins.
    - Captions should be 14-point centered.
    - The tables and figures of the paper should follow the APA citation style.
    - There should be no space between the caption and the table/figure.

12. **Footnotes**
    - Footnotes may be used only sparingly. A superscript numeral to refer to a footnote should be used in the text either directly after the word to be discussed or – in relation to a phrase or a sentence – following the punctuation mark (comma, semicolon, or period)
    - Footnotes should appear at the bottom of the page within the normal text area, with a line about 5 cm long immediately above them.
    - Footnotes should be 10-point and aligned left.

13. **References**
    - The author-date method in-text citation should be used. Following the APA format, the author's last name and the year of publication for the source should appear in the text.

    - All references that are cited in the text must be given in the reference list. The references must be in APA format (7th edition) and arranged alphabetically at the end of the paper.

Sample:

Surname, A. A. (year). Article title. *Title of Journal, volume number*(issue number), inclusive page numbers.doi URL/web address

Surname, A. A. (year). *Title of book.* Publisher Name. doi URL/web address

Surname, A. A., Surname, B. B., & Surname, C. C. (2000). Title of article. *Title of periodical, volume number*(issue number). doi URL/web address

Surname, A.A. (Year, Month). *Title of paper.* Paper presented at name of conference, city, country.

14. **Length**
    The paper should be 3,000-7,000 words including tables, figures, and references.

Author's Guide

The International Journal on Open and Distance e-Learning (IJODeL) welcomes original research articles, book reviews, theories, and best practices pertaining to ODeL worldwide. Articles should be 3,000-7,000 words including tables, figures, and references.

1. A publishable quantitatively-oriented paper should contain the following:
2. Abstract
3. Introduction
4. Objectives
5. Conceptual/Theoretical Framework
6. Methodology
7. Results and Discussions
8. Conclusions and Recommendations
9. References

Go to: Quantitatively-Oriented Journal Article Template

A publishable qualitatively-oriented paper should contain the following:
1. Abstract
2. Introduction
3. Objectives of the Study
4. Relevant Studies or Review of Related Studies
5. Discussions
6. Conclusions
7. Recommendations
8. References

Go to: Qualitatively-Oriented Journal Article Template

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