International Journal of Evaluation and Research in Education (IJERE)
Vol. 15, No. 6, December 2026, pp. 5273~5285
ISSN: 2252-8822, DOI: 10.11591/ijere.v15i6.40282

Flexible learning during energy crisis in Philippine higher education

Rotsenia J. Callao[1], Margarito B. Callao[1], Adrian P. Ybañez[1,2], Jennifer B. Carillo[1], Romeo C. Lepiten[1], Rose Mary L. Almacen[3], Rowena P. Dato-on[4], Ryan O. Tayco[5], Benjamin S. Villagonzalo Jr.[6], Dawn Iris Calibo-Senit[7]

[1]College of Veterinary Medicine and Institute for Molecular Genetics, Parasitology, and Vector-borne Diseases, Cebu Technological University-Barili Campus, Barili, Philippines
[2]Institute for Molecular Genetics, Parasitology, and Vector-borne Diseases, Cebu Technological University, Cebu City, Philippines
[3]Office of the Campus Director, Cebu Technological University-Danao Campus, Danao City, Philippines
[4]Office of the Campus Director, Cebu Technological University-Daanbantayan Campus, Daanbantayan, Philippines
[5]Office of the Campus Director, Negros Oriental State University, Dumaguete City, Philippines
[6]Office of the Research Director, Negros Oriental State University, Dumaguete City, Philippines
[7]Office of the Research Director, Siquijor State College, Siquijor, Philippines

Article Info

Article history:

Received May 5, 2026
Revised Sep 18, 2026
Accepted Oct 18, 2026

Keywords:

Digital divide
Energy emergency
Energy-resilient pedagogy
Flexible learning
Higher education
Philippines

ABSTRACT

Energy-related infrastructure disruptions can weaken higher education access by affecting electricity-dependent connectivity, device charging, transport, and household study routines. This mixed-methods study examined students' flexible-learning perceptions during the 2026 Philippine national energy emergency and evaluated follow-up support for a retained four-domain flexible learning system (FLS) monitoring tool. A voluntary campus-wide electronic survey collected 852 responses from one Cebu Technological University campus from April 16 to 20, 2026 using a 26-item four-point Likert questionnaire and three open-ended questions. Analyses included descriptive statistics, reliability analysis, exploratory and confirmatory factor analyses, HC3-robust models, multivariate tests, Chi-square tests, domain correlations, internet-speed comparisons, item diagnostics, and five-coder thematic analysis. The FLS context was multimodal, with printed modules, television, online streaming, and learning management system (LMS)-based activities reported. Poor or slow internet was reported by 77.3% of students and significantly differentiated support, resources, and readiness scores. Qualitative themes explained these patterns by linking connectivity problems with access burden, self-paced preference, and participation difficulty. Findings support cautious use of the FLS for low-stakes monitoring and suggest low-bandwidth, offline-compatible pedagogy for similar disruption-sensitive settings.

This is an open access article under the CC BY-SA license.

Corresponding Author:

Adrian P. Ybañez
College of Veterinary Medicine and Institute for Molecular Genetics, Parasitology, and Vector-borne Diseases, Cebu Technological University
Cebu City 6000, Philippines
Email: dr.adrianpybanez@gmail.com

1. INTRODUCTION

Flexible learning has become a continuity strategy in Philippine higher education when face-to-face operations are disrupted by public emergencies, infrastructure stress, or institutional constraints [1]. In March 2026, the Philippine government directed agencies to adopt energy-conservation protocols, reduce

non-essential travel, and use virtual coordination during the national energy emergency; in April 2026, the Commission on Higher Education advised higher education institutions to implement flexible learning during the same emergency [2]–[4]. For students, these directives interacted with electricity-dependent study conditions because device charging, internet use, communication with teachers, household lighting, and transport decisions influence whether students can participate in scheduled and asynchronous learning. The present study therefore treats the energy emergency as an infrastructure-disruption context that may intensify existing access gaps, not as evidence that all observed learning difficulties were caused directly by energy supply problems.

Philippine studies during the COVID-19 period showed that flexible learning can sustain academic continuity, but they also documented uneven readiness across institutions and student groups [5], [6]. Students often value flexibility, autonomy, and continuity, yet they also encounter unstable connectivity, data costs, limited interaction, and non-conducive home learning environments [7], [8]. International evidence similarly indicates that emergency remote teaching and blended learning protect continuity only when technology, pedagogy, and institutional support are adequate [9], [10]. For this reason, flexible learning during crisis conditions should be interpreted as a question of educational equity and institutional resilience rather than only as a choice of modality [11], [12].

The present study is guided by a crisis-responsive pedagogy perspective in which disruption conditions shape students' opportunity to learn through resource access, institutional support, self-regulated learning readiness, and barriers in daily study conditions. Resource access matters because students cannot participate meaningfully in flexible learning without usable devices, internet connectivity, power for charging, and learning materials [7], [8]. Support matters because instructional clarity, feedback, guidance, and accessible materials help students persist when formal learning routines are weakened [6], [9]. Readiness matters because crisis-responsive flexible learning places greater weight on motivation, time management, persistence, and learner agency under constrained supervision [13]–[15].

Flexible learning during disruption is not explained solely by access to technology. Students can experience the same platform ecology differently depending on teacher responsiveness, assessment design, emotional strain, household conditions, and their ability to self-regulate under pressure [16], [17]. Crisis-responsive higher education literature emphasizes that continuity depends on the interaction among technology, pedagogy, social support, and local constraints [18], [19]. In an energy-limited context, this interaction becomes more technical because electricity supply, internet availability, device charging, institutional server access, and communication channels together determine whether digital learning can function.

The novelty of this study lies in its analysis of flexible-learning perceptions during a non-pandemic national energy-emergency period, where education continuity was discussed against electricity-dependent connectivity, device use, and transport constraints rather than against pandemic closure alone. The study generates new contextual knowledge by showing that familiar flexible-learning issues, particularly connectivity, modality exposure, support, resources, and readiness, acquired an energy-sensitive interpretation: they functioned as indicators of access burden and continuity capacity during an infrastructure-sensitive period, not merely as ordinary online-learning concerns. It also extends prior pandemic-era flexible learning system (FLS) monitoring work by showing that support, resources and digital proficiency, and readiness remained coherent domains in this newer context, whereas barriers and challenges remained heterogeneous and required refinement. These findings support an energy-resilient pedagogy perspective in which flexible learning should be designed for low-bandwidth, lower-power, and offline-compatible continuity while avoiding causal claims that were not directly measured [20]–[22].

The study addressed three linked research questions. The first asked how college students in one campus of Cebu Technological University perceived flexible learning during the energy-emergency period in terms of support, resources, readiness, barriers, and preferred modes. The second asked whether the previously retained four-domain structure of the FLS questionnaire would receive follow-up psychometric support in this single-campus energy-emergency sample. The third asked how quantitative domain patterns were clarified by thematic evidence from students' concerns, crisis-related challenges, and reasons for their mode preferences, consistent with mixed-methods guidance that numerical patterns should be interpreted alongside narrative evidence [17], [23].

2. METHOD

2.1. Research design and setting

This study used a cross-sectional mixed-methods design with an embedded qualitative component and a follow-up psychometric support analysis of the FLS questionnaire. Quantitative and qualitative data were collected concurrently and integrated at the interpretation stage, consistent with mixed-methods designs that use qualitative evidence to explain or contextualize numerical patterns [23]. The study was conducted in

one campus of Cebu Technological University in Cebu, Philippines, during the national energy emergency and shortly after the Commission on Higher Education issued its April 7, 2026 advisory on flexible learning during that emergency [2]. The study examined student perceptions and reported access conditions during this period, but it did not directly measure household-level electricity interruption, outage duration, energy consumption, or individual exposure to power disruptions. Accordingly, the design supports contextual interpretation of FLS experiences during an energy-emergency period rather than causal attribution of all observed constraints to energy disruption.

2.2. Respondents and recruitment

All enrolled students on the campus were invited to participate through an official campus memorandum. Participation was voluntary, no incentives were provided, and the resulting dataset should be interpreted as a volunteer sample from a campus-wide invitation rather than as a probability sample. The quantitative dataset contained 852 responses, although valid n differed slightly across some profile variables because not all items were answered by all respondents. Because data were collected through an electronic survey during an energy-emergency period, students with the most severe electricity, connectivity, or device-access constraints may have been underrepresented.

2.3. Research instrument

The survey consisted of a 26-item closed-ended questionnaire scored on a four-point Likert scale from 1=strongly disagree to 4=strongly agree. The questionnaire was adapted from a previously used FLS monitoring tool developed during the COVID-19 flexible-learning period. In the present study, students were asked to evaluate whether flexible-learning experiences and challenges that became prominent during the pandemic remained present during the current energy-emergency context. Thus, the instrument was not treated as a newly developed scale but as a retained monitoring questionnaire examined for follow-up support in a non-pandemic infrastructure-disruption setting.

The instrument was retained as a four-domain monitoring measure because the study's theoretical framing and instrument history favored domain-level interpretation over a single global score for low-stakes monitoring. The retained domains were support with 11 items, resources and digital proficiency with five items, readiness for self-regulated learning with six items, and barriers and challenges with four items. The barriers scale was coded in the original problem-oriented direction, so higher scores indicate greater perceived barriers rather than more adaptive conditions. Because this domain was expected to capture diverse access, household, and learning-condition problems, particular caution was applied in interpreting barriers and in examining item-level diagnostics.

2.4. Qualitative component

The qualitative component used the three open-ended questions aligned with the study aims: concerns about flexible learning, barriers experienced during the energy-emergency period, and reasons for preferred learning mode. A preliminary theme list was developed from the first 50 responses and was expanded as newer themes emerged from the complete dataset. An additional round of analysis was completed with five coders using a majority-consensus workflow. Pairwise agreement was 0.643 overall and 0.720, 0.676, and 0.521 for the three questions, indicating moderate to high agreement overall and stronger theme reliability for concerns and challenges than for learning-mode reasons.

2.5. Data collection and analysis

Data were collected from April 16 to April 20, 2026 through an electronic survey disseminated under the formal campus memorandum. The flexible-learning implementation was examined as a multimodal system rather than as a single online platform because students reported printed modules, television, online streaming, storage devices, video recordings, radio broadcasting, LMS use, Google Classroom, and live online teaching. The electronic survey also collected demographic characteristics, learning-technology experience, device access, internet speed, internet service provider, digital literacy, and modality exposure or ratings. Household size and shared-device responses were checked for implausible or non-numeric entries, and raw family-income responses were not categorized for formal analysis because respondents mixed annual and monthly units too inconsistently for reliable grouping.

Internal consistency was assessed using Cronbach’s alpha. Follow-up psychometric support was examined using exploratory factor analysis through principal axis factoring with Promax rotation and confirmatory factor analysis (CFA) comparing one-factor and retained four-factor models, consistent with common psychometric practice for multidimensional questionnaires [24], [25]. Additional supportive analyses included HC3-robust univariate and adjusted ordinary least squares models, multivariate omnibus tests, Chi-square tests with Cramer’s V for profile-technology associations, Pearson domain correlations, internet-speed comparisons of domain scores using Welch tests, modality summaries, and corrected

item-total diagnostics for the barriers and challenges domain. HC3-robust standard errors were used to reduce sensitivity to heteroskedasticity in survey data, and Pillai's trace was emphasized for multivariate testing because it is relatively robust under common educational-data assumption violations [26].

2.6. Ethical considerations

Participation was voluntary, and students were informed that they could decline participation without penalty. The working dataset was treated as an anonymized student-response archive for analysis and reporting. Informed consent was obtained before participation, and the study protocol was reviewed and approved by the CTU-Local Research Ethics Committee under approval number DB-2026-005.

3. RESULTS AND DISCUSSION

3.1. Follow-up psychometric support for the four-domain structure

A follow-up psychometric evaluation was conducted using the 852-response energy-emergency sample to examine whether the retained four-domain structure of the FLS questionnaire received support in this disruption context. The inter-item matrix showed excellent sampling adequacy, with KMO=0.943 and a significant Bartlett's test of sphericity, Chi-square (325)=9406.06, $p<0.001$. These results indicated that the items shared sufficient common variance for factor analysis and justified proceeding with exploratory and confirmatory analyses as follow-up support rather than de novo scale development. This approach is consistent with psychometric guidance that retained multidimensional instruments should be examined through factorability, exploratory structure, and model fit before domain-level interpretation is emphasized [24], [25]. Because the same sample was used for exploratory and confirmatory stages, these results should be interpreted as within-sample follow-up support rather than as stronger external replication evidence.

Exploratory factor analysis using principal axis factoring with Promax rotation supported a four-factor solution. The first four eigenvalues were 9.41, 1.88, 1.55, and 1.15, and the extracted solution accounted for 45.52% of the total variance. The pattern was broadly consistent with the retained domains of support, resources and digital proficiency, readiness for self-regulated learning, and barriers and challenges. This multidimensional result agrees with emergency remote teaching and flexible-learning literature showing that student experience is shaped by technology access, instructional design, support, and learner readiness rather than by one general perception alone [9], [10], [14]. The resource-related factor was the cleanest, whereas the barriers factor remained the least homogeneous.

CFA showed that the four-factor model fit substantially better than the one-factor model. The one-factor model fit poorly, whereas the four-factor model achieved acceptable comparative fit and a lower residual index, supporting multidimensional interpretation of FLS perceptions. Reliability estimates were high for support, resources and digital proficiency, and readiness for self-regulated learning, but remained modest for barriers and challenges. These findings are consistent with measurement theory, which cautions that domains combining heterogeneous constraints may show weaker internal consistency even when they remain useful for formative monitoring [24], [25]. The result also aligns with studies of online and flexible learning in which barriers include several distinct problems, such as connectivity, workload, device access, home environment, and platform difficulty [5], [7], [8], [14]. These findings support the questionnaire as a group-level monitoring tool while requiring careful interpretation and further refinement of the barriers domain, particularly because heterogeneous and problem-oriented items may capture different types of constraints rather than one stable construct, as seen in Table 1.

Table 1. Follow-up psychometric support for the FLS questionnaire

Indicator	Result reported in the manuscript	Interpretation
Sampling adequacy	KMO=0.943	Excellent factorability
Bartlett's test	$\chi^2(325)=9406.06$, $p<0.001$	Inter-item correlations were sufficient for factor analysis
Exploratory factor analysis	Four-factor solution; variance explained=45.52%	Broadly consistent with retained domains
One-factor CFA	CFI=0.836; TLI=0.822; RMSEA=0.114; SRMR=0.082	Poorer fit
Four-factor CFA	CFI=0.907; TLI=0.897; RMSEA=0.087; SRMR=0.064	Substantially better fit
Reliability	Support α=0.875; Resources α=0.836; Readiness α=0.843; Barriers α=0.634	Three stable domains and one weaker domain

3.2. Respondent profile, learning technologies, and connectivity setting

The respondent group was predominantly female, and students aged 20-21 years represented the largest age group. The largest program cluster was education, followed by agriculture and fisheries,

engineering and technology, and business and management. Among categorized household-size responses, households with five to seven members were most common, although some household-size responses required data-quality checking because non-numeric or implausible entries were present. Most respondents had prior experience with the learning management system (LMS) before the energy crisis, and some reported sharing a gadget with household members during the crisis, as presented in Table 2. These patterns should be read as characteristics of a voluntary campus sample because flexible-learning studies commonly report that access, response opportunity, program context, and device availability can shape who participates in online or electronic surveys [5], [7], [8].

The learning-technology context during the energy-emergency period was multimodal rather than online-centered. Printed modality was the most widely reported mode, followed by television, other modalities, online streaming, and LMS use, indicating that instructional delivery was adjusted around feasible access rather than a single digital platform. Connectivity remained the dominant campus-wide constraint, with 77.3% of respondents reporting poor or slow internet connection, making internet speed a key marker of digital-access inequality observed during the energy-emergency period, as shown in Figure 1. This pattern is comparable to Philippine flexible-learning studies in which unstable internet, data cost, limited device access, and uneven rural or household learning conditions constrained participation despite the availability of online platforms [5], [7], [8], [27], [28]. However, this pattern should be interpreted as an access condition observed during the emergency period rather than as proof that the emergency itself created all connectivity problems.

Table 2. Respondent profile (n=852)

Area	Key value or pattern reported	Interpretive note
Gender	Female respondents=73.0%	Predominantly female volunteer sample
Age	20-21 years=45.1%	Largest age group
Program cluster	Education=44.6%	Largest represented college group

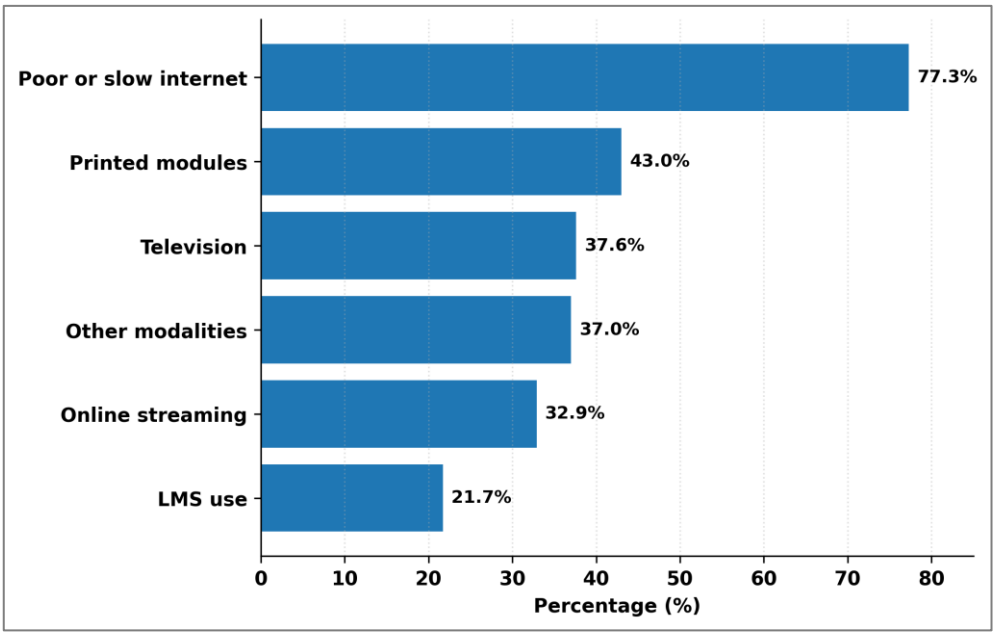


Figure 1. Learning-technology and connectivity context during the energy-emergency flexible learning period

3.3. Item and domain patterns

Item-level patterns reflected generally favorable perceptions of instructional delivery, feedback, module preparation, self-discipline, and motivation. The highest positive perceptions were observed for satisfaction with instructional delivery and desire to continue studies, whereas internet access and online library access were among the weakest areas. Strong agreement on the need for additional distance-education training and on home distraction indicated that perceived instructional continuity coexisted with substantial pressure. This combination is consistent with prior Philippine and international studies showing that students

may value flexible learning for continuity and autonomy while still struggling with connectivity, interaction, workload, and learning-space limitations [5], [6], [8], [16]. Overall, the item pattern suggests that flexible learning was workable but uneven under the energy-emergency period.

At the domain level, support, resources and digital proficiency, and readiness for self-regulated learning showed moderate-to-favorable mean patterns, while barriers and challenges remained substantial for a meaningful subgroup. The largest high-level proportion was observed for readiness, followed by barriers and support. Since the barriers domain retained its original problem-oriented direction, higher scores indicated greater perceived burden rather than better learning conditions. This result extends self-regulated learning and self-determination perspectives by showing that readiness is not only an individual trait but is also supported by competence, autonomy, instructional clarity, and usable learning conditions [13], [15]. Domain-level results therefore indicate favorable readiness and support but persistent barriers, with the barriers and challenges domain treated as a cautionary monitoring signal rather than as a strong stand-alone construct because of its modest internal consistency, as shown in Table 3.

Table 3. Domain-level interpretation of FLS perceptions

Domain	Mean (SD); α	High level n (%)	Statistical interpretation
Support	2.871 (0.389); α=0.875	165 (19.4)	Stable domain; favorable support signal
Resources and digital proficiency	2.738 (0.523); α=0.836	121 (14.2)	Stable domain; access-related constraint signal
Readiness for self-regulated learning	2.910 (0.447); α=0.843	183 (21.5)	Stable domain; strongest favorable pattern
Barriers and challenges	2.852 (0.448); α=0.634	168 (19.7)	Modest reliability; heterogeneous barrier signal

Note: high-level proportion refers to respondents with domain mean scores greater than 3.00 on the four-point scale. Higher scores in barriers and challenges indicate greater perceived barriers.

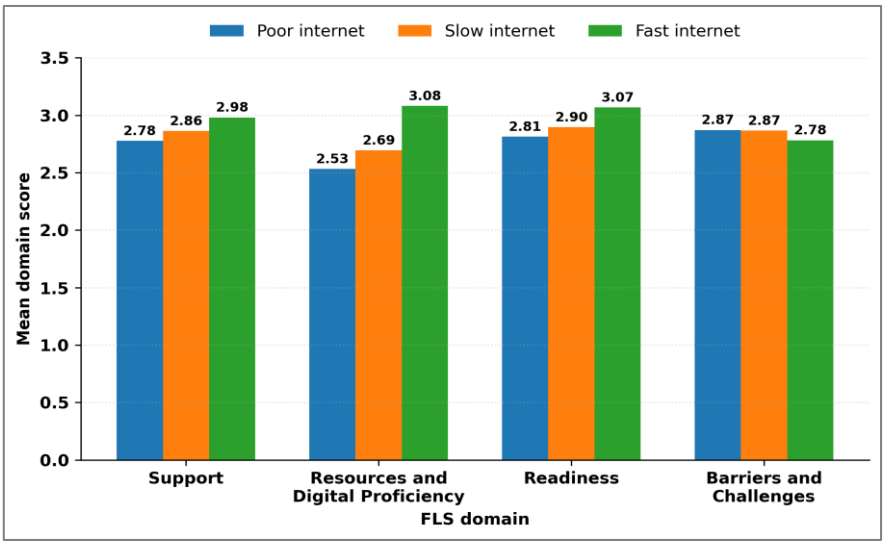
3.4. Inferential patterns and profile-technology associations

Univariate HC3-robust models identified internet speed as the strongest stable predictor across domains. Compared with fast internet speed, poor or slow internet was negatively associated with readiness, resources, and support, with the largest coefficient magnitudes reported for the resources domain. The added internet-speed comparison confirmed this interpretation: students with fast internet had higher mean support, resources, and readiness scores than students with poor or slow internet, and the differences were statistically significant for these three domains. These findings are consistent with previous studies in the Philippines and other emergency-learning settings where connectivity and device availability predicted students' ability to access content, communicate with teachers, submit tasks, and sustain engagement [5], [7]–[10]. Barriers scores were slightly lower among students with fast internet, but the internet-speed difference for barriers was not statistically significant, consistent with the interpretation that barriers reflected more heterogeneous constraints, as seen in Figure 2.

Domain correlations added educational meaning to the inferential results. Support, resources and digital proficiency, and readiness for self-regulated learning were strongly interrelated, particularly support-readiness (r=0.749), support-resources (r=0.659), and resources-readiness (r=0.658). This pattern suggests that students' capacity to self-regulate during disrupted learning may depend not only on individual motivation but also on usable learning resources and responsive instructional support. In practical terms, unreliable connectivity can weaken access to materials and feedback, and this weakened access may reduce students' confidence, time management, and persistence in flexible learning. This interpretation is consistent with self-regulated learning research and self-determination theory, which emphasize that learner persistence is strengthened when autonomy, competence, and supportive learning conditions are present [13], [15]. In contrast, barriers and challenges had weaker correlations with the other domains, ranging from r=0.172 to r=0.274, which supports the view that barriers represented a broader and less homogeneous set of student constraints.

Multivariate omnibus tests supported a similar interpretation. Internet speed was the strongest overall profile-level predictor, followed by year level, program group, and digital literacy. In adjusted HC3-robust models, poor or slow internet remained negatively associated with readiness, resources, and support, and poor internet again showed the strongest negative relation with resources. This pattern agrees with blended-learning and emergency remote teaching reviews showing that technology readiness, instructional support, program context, and student experience jointly influence learning continuity [9], [14], [18], [19]. Item diagnostics also confirmed that the barriers domain remained the weakest component, with corrected item-total correlations ranging from 0.327 to 0.491 and no item deletion improving the overall alpha of 0.634. These findings indicate that further instrument work should consider whether barriers and challenges

should be revised, reduced, or conceptually restructured into more specific subdomains, such as connectivity barriers, household-study barriers, emotional or motivational barriers, and platform-related barriers, as shown in Table 4 [24], [25].



Note: higher scores in the barriers and challenges domain indicate greater perceived barriers.

Figure 2. FLS domain scores by internet-speed category

Table 4. Summary of selected inferential and diagnostic findings

Analysis area	Main result reported	Implication
Domain correlations	Support-readiness r=0.749; support-resources r=0.659; resources-readiness r=0.658; barriers correlations with other domains r=0.172-0.274	Support, resources, and readiness formed a coherent favorable-learning pattern, whereas barriers were more heterogeneous
Univariate and adjusted HC3-robust models	Poor or slow internet remained negatively associated with readiness, resources, and support after covariate adjustment	Connectivity was the strongest stable predictor of FLS experience
Year level and digital literacy	Fourth year or higher showed more favorable relations with readiness, resources, and support; higher digital literacy was positively related to readiness and resources	Student experience and technology confidence supported flexible learning participation
Barriers-domain diagnostics	α=0.634; corrected item-total r=0.327-0.491; no item deletion improved the overall alpha	The Barriers domain should be treated as a preliminary monitoring signal and should be revised, reduced, or restructured in future applications

3.5. Qualitative integration and implications for higher education practice

The qualitative findings expanded the quantitative results by clarifying how connectivity became an access burden rather than a single technical inconvenience. Students' concerns and crisis-related challenges repeatedly referred to connectivity or internet problems, while reasons for preferred modes emphasized flexibility, convenience, self-paced access, and practicality. These themes help explain the strong correlations among support, resources, and readiness: when students could access materials, communicate with instructors, and manage submissions more reliably, support and resources became part of their capacity to self-regulate. This interpretation is consistent with mixed-methods guidance that qualitative evidence should explain how and why quantitative patterns occur, not simply repeat numerical results [17], [23]. It also agrees with studies showing that emergency remote and flexible learning become more sustainable when technological access, teacher support, and learner agency operate together [9], [10], [13]. Conversely, unreliable connectivity could weaken perceived support and readiness because students could not consistently download materials, receive feedback, submit tasks, or organize self-paced study, as in Table 5.

The same qualitative pattern also helps explain why the barriers and challenges domain performed more weakly than the other domains. Students did not describe barriers as one uniform problem, but as overlapping constraints involving internet access, home distraction, platform difficulty, training needs, and mode-specific participation burden. This heterogeneity is consistent with the lower reliability and weaker domain correlations of barriers and supports future refinement into more specific subdomains rather than

treating barriers as a single stable construct. Similar heterogeneity has been reported in flexible-learning and online-learning studies where barriers combined technical, pedagogical, household, emotional, and institutional constraints [5], [8], [14], [16], [29]. Thus, the qualitative strand did more than confirm the quantitative results; it clarified why favorable conditions clustered more coherently than barriers.

The national energy-emergency period provides the context for interpreting why printed modules, television, online streaming, and other low- or mixed-bandwidth arrangements remained prominent, although the data do not demonstrate direct effects of individual power interruptions. Prior Philippine flexible-learning studies have already documented access, readiness, modality fit, instructional support, and institutional infrastructure as recurring concerns across graduate education, physical education, lived-experience studies, online learning, adoption studies, readiness studies, modular learning, and virtual-learning environments [27]–[36]. The present findings add to that literature by situating those familiar concerns within a non-pandemic energy-emergency period and by emphasizing their relevance for energy-sensitive continuity planning rather than treating them only as ordinary online-learning constraints. Government energy-conservation directives and the higher education advisory created a policy environment in which institutions were encouraged to preserve academic continuity while managing travel, electricity-dependent communication, and digital readiness [2], [3]. This interpretation also aligns with resilience-oriented e-learning literature, which suggests that educational systems should be able to continue operating after disruptions by shifting to feasible, lower-resource arrangements [21], [22]. For similar infrastructure-sensitive settings, the practical implication is not simply to increase online delivery but to design FLS arrangements that can shift from full online access to mobile-accessible, downloadable, printed, or asynchronous alternatives without losing essential learning outcomes [18], [19].

Table 5. Majority-consensus qualitative themes from open-ended responses

Open-ended area	Dominant theme or pattern	Reported value or interpretation
Concerns about FLS	Connectivity or internet problems	57.1% of coded responses
Crisis-related learning challenges	Connectivity or internet problems	74.6% of coded responses
Reasons for preferred learning mode	Flexibility, convenience, practicality, and self-paced access	Students favored modes that reduced access burden
Integrated interpretation	Connectivity linked concerns, challenges, and mode preference	Qualitative data explained how access burden shaped domain patterns and mode preference

Note: Percentages refer to coded responses under the majority-consensus coding procedure.

3.6. Limitations

The study used a cross-sectional volunteer sample from one campus of Cebu Technological University, so the findings should not be generalized to all students in the university system or to all higher education institutions in the Philippines. The data were self-reported and may be affected by perception, recall, and social desirability biases. Students with the most severe electricity, connectivity, or device-access constraints may also have been underrepresented because the survey was electronic despite the campus-wide invitation. These limitations are consistent with concerns in survey-based flexible-learning research, where online recruitment can underrepresent learners with the weakest access conditions [5], [7], [8]. The study measured student perceptions and reported access conditions during the national energy emergency, but it did not directly measure household-level power interruption, outage duration, energy expenditure, or objective internet performance. This limitation is central to the interpretation of the findings: the analysis supports contextual claims about FLS during the energy-emergency period, but it does not establish causal effects of power interruptions on students' learning experiences. The questionnaire was reused to examine whether flexible-learning challenges remained visible in a non-pandemic disruption setting, but some items may retain pandemic-era assumptions that require further adaptation for energy-related, climate-related, transport-related, and other infrastructure-sensitive emergencies. The same sample was used for exploratory and confirmatory psychometric analyses, and the barriers and challenges domain showed only modest reliability, so future work should validate the instrument across additional campuses and crisis settings, refine or restructure the barriers domain, and examine whether low-bandwidth curricula and community-based digital access support can reduce exclusion during infrastructure-sensitive emergencies [24], [25].

4. CONCLUSION

Flexible learning during the national energy-emergency period in the studied campus was workable but uneven because students reported generally favorable instruction, module preparation, and self-regulation while connectivity and resource constraints remained central within a multimodal learning environment.

The retained FLS monitoring tool received follow-up support as a four-domain instrument for low-stakes group monitoring, with stronger evidence for support, resources and digital proficiency, and readiness for self-regulated learning than for barriers and challenges, which requires further refinement. The findings move flexible-learning research beyond pandemic-centered emergency remote teaching by showing how infrastructure-sensitive contexts can coincide with access, modality exposure, and educational-equity concerns. However, because the study did not directly measure household-level power interruption and used a voluntary single-campus electronic survey, the findings should inform cautious planning for similar contexts rather than broad causal claims about Philippine higher education. Higher education institutions in comparable disruption-sensitive settings should develop low-bandwidth and offline-compatible flexible-learning systems, including downloadable materials, flexible deadlines during unstable connectivity, mobile-accessible communication, and continuity plans that allow instruction to shift across higher- and lower-power modes without losing essential learning outcomes. Future research should validate the refined instrument across multiple campuses and disruption contexts and examine whether energy-agnostic curricula and community-based digital access support can reduce exclusion during infrastructure-sensitive emergencies.

ACKNOWLEDGMENTS

The authors thank the students who voluntarily participated in the survey, and the faculty and administrative personnel of CTU-Barili Campus for supporting survey coordination during the energy-emergency period. Their assistance helped facilitate data collection while preserving voluntary participation and anonymized analysis. The authors also acknowledge the institutional support that enabled timely documentation of flexible-learning experiences during this disruption-sensitive period.

FUNDING INFORMATION

The study was partially funded by Cebu Technological University General Appropriations Act (GAA) funds. The funding supported institutional research activities related to survey implementation, data processing, and manuscript preparation. The authors remain responsible for the interpretation of the anonymized data and the content of the manuscript.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Rotsenia J. Callao	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Margarito B. Callao	✓	✓	✓	✓		✓	✓		✓	✓	✓		✓	✓
Adrian P. Ybañez	✓	✓				✓		✓	✓	✓	✓	✓	✓	
Jennifer B. Carillo					✓	✓			✓	✓	✓			
Romeo C. Lepiten					✓	✓			✓	✓	✓			
Rose Mary L. Almacen					✓	✓			✓	✓	✓			
Rowena P. Dato-on					✓	✓			✓	✓	✓			
Ryan O. Tayco					✓	✓			✓	✓	✓			
Benjamin S. Villagonzalo Jr.					✓	✓			✓	✓	✓			
Dawn Iris Calibo-Senit					✓	✓			✓	✓	✓			

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest. The study was conducted as academic research within the authors' institutional responsibilities. No personal, commercial, or financial relationship is reported that could have influenced the conduct or reporting of the study.

INFORMED CONSENT

Informed consent was obtained from all participants before participation. Students were informed that participation was voluntary and that their responses would be analyzed in anonymized form. No incentive was provided, and non-participation did not result in academic penalty.

ETHICAL APPROVAL

The study protocol was reviewed and approved by the CTU-Local Research Ethics Committee under approval number DB-2026-005. The ethical review covered voluntary participation, informed consent, anonymized analysis, and institutional data handling. The study was conducted in accordance with applicable campus and university research ethics procedures.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to applicable institutional and ethics requirements. Access may be limited to protect participant confidentiality and comply with the conditions of ethics approval. Requests for data should specify the intended scholarly purpose and will be evaluated according to institutional procedures.

REFERENCES

[1] J. J. B. Joaquin, H. T. Biana, and M. A. Dacela, "The Philippine Higher Education Sector in the Time of COVID-19," *Frontiers in Education*, vol. 5, Oct. 2020, doi: 10.3389/feduc.2020.576371.

[2] Commission on Higher Education (CHED), "CHED Advisory on the Implementation of Flexible Learning during the National Energy Emergency." Memorandum from the Office of the Chairperson No. 117, Philippines, 2026. [Online]. Available: https://cms-cdn.e.gov.ph/CHED/pdf/MOC-NO-117-S-2026.pdf

[3] Office of the President, "Directing All Government Agencies and Instrumentalities to Strictly Adopt Energy Conservation Protocols," 2026. [Online]. Available: https://pco.gov.ph/wp-content/uploads/2026/03/20260306-MC-114-FRM.pdf

[4] Presidential Communications Office, "PBBM Urges Gov't Personnel to Conduct Virtual Meetings, Instead of Travel," 2026. [Online]. Available: https://pco.gov.ph/news_releases/pbbm-urges-govt-personnel-to-conduct-virtual-meetings-instead-of-travel/

[5] J. S. Barrot, I. I. Llenares, and L. S. del Rosario, "Students' Online Learning Challenges during the Pandemic and How They Cope with Them: The Case of the Philippines," *Education and Information Technologies*, vol. 26, no. 6, pp. 7321–7338, Nov. 2021, doi: 10.1007/s10639-021-10589-x.

[6] F. T. Dayagbil, D. R. Palompon, L. L. Garcia, and M. M. J. Olvido, "Teaching and Learning Continuity Amid and Beyond the Pandemic," *Frontiers in Education*, vol. 6, Jul. 2021, doi: 10.3389/feduc.2021.678692.

[7] J. M. R. Asio, E. Gadia, E. Abarintos, D. Paguio, and M. Balce, "Internet Connection and Learning Device Availability of College Students: Basis for Institutionalizing Flexible Learning in the New Normal," *Studies in Humanities and Education*, vol. 2, no. 1, pp. 56–69, Jun. 2021, doi: 10.48185/she.v2i1.224.

[8] T. E. Gocotano, M. A. L. Jerodiaz, J. C. P. Banggay, H. B. R. Nasibog, and M. B. Go, "Higher Education Students' Challenges on Flexible Online Learning Implementation in the Rural Areas: A Philippine Case," *International Journal of Learning, Teaching and Educational Research*, vol. 20, no. 7, pp. 262–290, Jul. 2021, doi: 10.26803/ijlter.20.7.15.

[9] M. Bond, S. Bedenlier, V. I. Marín, and M. Händel, "Emergency Remote Teaching in Higher Education: Mapping the First Global Online Semester," *International Journal of Educational Technology in Higher Education*, vol. 18, no. 1, p. 50, Dec. 2021, doi: 10.1186/s41239-021-00282-x.

[10] F. Ferri, P. Grifoni, and T. Guzzo, "Online Learning and Emergency Remote Teaching: Opportunities and Challenges in Emergency Situations," *Societies*, vol. 10, no. 4, p. 86, Nov. 2020, doi: 10.3390/soc10040086.

[11] V. Ahmed and A. Opoku, "Technology Supported Learning and Pedagogy in Times of Crisis: The Case of COVID-19 Pandemic," *Education and Information Technologies*, vol. 27, no. 1, pp. 365–405, Jan. 2022, doi: 10.1007/s10639-021-10706-w.

[12] C. M. Toquero, "Challenges and Opportunities for Higher Education amid the COVID-19 Pandemic: The Philippine Context," *Pedagogical Research*, vol. 5, no. 4, p. em0063, Apr. 2020, doi: 10.29333/pr/7947.

[13] F. Biwer *et al.*, "Changes and Adaptations: How University Students Self-Regulate Their Online Learning During the COVID-19 Pandemic," *Frontiers in Psychology*, vol. 12, Apr. 2021, doi: 10.3389/fpsyg.2021.642593.

[14] R. A. Rasheed, A. Kamsin, and N. A. Abdullah, "Challenges in the Online Component of Blended Learning: A Systematic Review," *Computers and Education*, vol. 144, p. 103701, Jan. 2020, doi: 10.1016/j.compedu.2019.103701.

[15] R. M. Ryan and E. L. Deci, "Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being," *American Psychologist*, vol. 55, no. 1, pp. 68–78, 2000, doi: 10.1037/0003-066X.55.1.68.

[16] C. Coman, L. G. Țîru, L. Meseșan-Schmitz, C. Stanciu, and M. C. Bularca, "Online Teaching and Learning in Higher Education during the Coronavirus Pandemic: Students' Perspective," *Sustainability (Switzerland)*, vol. 12, no. 24, pp. 1–22, Dec. 2020, doi: 10.3390/su122410367.

[17] S. Manca and M. Delfino, "Adapting Educational Practices in Emergency Remote Education: Continuity and Change from a Student Perspective," *British Journal of Educational Technology*, vol. 52, no. 4, pp. 1394–1413, Jul. 2021, doi: 10.1111/bjet.13098.

[18] S. Affouneh, S. Salha, and Z. N. Khlaif, "Designing Quality E-Learning Environments for Emergency Remote Teaching in Coronavirus Crisis," *Interdisciplinary Journal of Virtual Learning in Medical Sciences*, vol. 11, no. 2, pp. 135–137, 2020, doi: 10.30476/ijvlms.2020.86120.1033.

[19] S. Pokhrel and R. Chhetri, "A Literature Review on Impact of COVID-19 Pandemic on Teaching and Learning," *Higher Education for the Future*, vol. 8, no. 1, pp. 133–141, Jan. 2021, doi: 10.1177/2347631120983481.

[20] T. Trust and J. Whalen, "Should Teachers Be Trained in Emergency Remote Teaching? Lessons Learned from the COVID-19 Pandemic," *Journal of Technology and Teacher Education*, vol. 28, no. 2, pp. 189–199, 2020, doi: 10.70725/307718pkpjuu.
[21] K. Ayebi-Arthur, "E-Learning, Resilience and Change in Higher Education: Helping a University Cope after a Natural Disaster," *E-Learning and Digital Media*, vol. 14, no. 5, pp. 259–274, 2017, doi: 10.1177/2042753017751712.
[22] C. Müller and T. Mildenberger, "Facilitating Flexible Learning by Replacing Classroom Time with an Online Learning Environment: A Systematic Review of Blended Learning in Higher Education," *Educational Research Review*, vol. 34, p. 100394, Nov. 2021, doi: 10.1016/j.edurev.2021.100394.
[23] J. W. Creswell and V. L. P. Clark, *Designing and conducting mixed methods research*, 3rd ed. Thousand Oaks, CA, USA: SAGE Publications, Inc., 2018.
[24] T. A. Brown, *Confirmatory factor analysis for applied research*, 2nd ed. New York, NY: The Guilford Press, 2015.
[25] R. B. Kline, *Principles and practice of structural equation modeling*, 4th ed. New York: The Guilford Press, 2016.
[26] A. F. Hayes and L. Cai, "Using Heteroskedasticity-Consistent Standard Error Estimators in OLS Regression: An Introduction and Software Implementation," *Behavior Research Methods*, vol. 39, no. 4, pp. 709–722, Nov. 2007, doi: 10.3758/BF03192961.
[27] M. D. Junsay and G. B. Lagura, "Flexible Learning in Graduate Education of State Universities and Colleges in the Davao Region, Philippines," *The Palawan Scientist*, vol. 16, no. 2, pp. 57–70, Jul. 2024, doi: 10.69721/TPS.J.2024.16.2.06.
[28] E. Cajurao, M. Ogaya, C. Almonicar, Jr., G. Abella, and J. Escalante, "Exploring Factors Affecting the Adoption of Flexible Learning Modality by Public University Students in Masbate, Philippines," *East Asian Journal of Multidisciplinary Research*, vol. 2, no. 3, pp. 1313–1326, Mar. 2023, doi: 10.55927/eajmr.v2i3.3473.
[29] L. Giray, D. Gumalin, J. Jacob, and K. Villacorta, "Exploring the Online Learning Experience of Filipino College Students During Covid-19 Pandemic," *Jurnal Ilmiah Peuradeun*, vol. 10, no. 1, pp. 227–250, 2022, doi: 10.26811/peuradeun.v10i1.691.
[30] H. C. Dimarucot, J. C. Aguinaldo, and E. C. A. Andres, "Flexible Learning in College Physical Education in the Time of a Global Health Crisis and Beyond," *International Journal of Human Movement and Sports Sciences*, vol. 9, no. 5, pp. 1058–1066, Sep. 2021, doi: 10.13189/saj.2021.090528.
[31] J. E. Delgado and J. Arellano, "A Phenomenological Study of the Lived Experiences of Graduate Students Adapting Flexible Learning Modality Due to COVID-19 Pandemic," *Asian Journal of Education and Social Studies*, pp. 7–16, Mar. 2021, doi: 10.9734/ajess/2021/v15i430385.
[32] J. B. B. Omaweng, "Readiness of Apayao State College-Conner Campus to Flexible Learning Modalities," *Asian Journal of Education and Social Studies*, pp. 46–52, Aug. 2022, doi: 10.9734/ajess/2022/v32i230767.
[33] J. S. Camara, "The Ecosystem of Online Learning in the Philippine Setting: A Case of Pangasinan State University," *Journal for Educators, Teachers and Trainers*, vol. 13, no. 1, Jan. 2022, doi: 10.47750/jett.2022.13.01.033.
[34] M. S. Tugano, J. Z. Tria, and J. Z. Tonio, "Modular Learning amidst COVID-19 Pandemic: Satisfaction Among Students in a Higher Education Institution," *International Journal of Professional Development, Learners and Learning*, vol. 4, no. 2, p. ep2206, May 2022, doi: 10.30935/ijpdll/12075.
[35] J. A. M. Petancio, A. M. Pogoy, I. C. Montalbo, and G. M. Pepito, "Virtual Learning Environment in a Philippine Higher Education Institution: Acceptance and Practices," *International Journal of Information and Education Technology*, vol. 14, no. 5, pp. 712–720, 2024, doi: 10.18178/ijiet.2024.14.5.2096.
[36] F. F. Patacsil, P. Dina, and B. Roaring, "Analyzing Flexible Learning Implementation Using Decision Tree Approach," *Journal of Educational Science and Technology (EST)*, vol. 9, no. 2, p. 103, Aug. 2023, doi: 10.26858/est.v9i2.36677.

BIOGRAPHIES OF AUTHORS



Rotsenia J. Callao holds a Doctorate in Development Education and is the dean of student affairs and services at Cebu Technological University–Barili Campus, where she holds the academic rank of associate professor V. With over 34 years of experience in teaching and academic leadership, she has contributed to educational administration, student development, and faculty mentoring. Her research focuses on instructional and administrative leadership, teacher performance, and professional development. She remains actively engaged in research and training, leading initiatives that enhance instructional quality and effective school leadership. She can be contacted at email: rotsie.callao@gmail.com.



Margarito B. Callao is an associate professor I and full-time faculty member of Cebu Technological University - Barili Campus, where he is associated with the Bachelor of Secondary Education major in Science program. He holds a Bachelor of Secondary Education major in Mathematics from the University of Mindanao, a Master of Arts in Education major in Educational and Leadership Management, a Master of Arts in Teaching major in Mathematics, and a Doctor of Public Administration from Southwestern University, as well as a Doctor in Development Education from Cebu Technological University. His academic and research interests include mathematics and science education, educational management, and public administration. He can be contacted at email: margarito.callao@ctu.edu.ph.



Adrian P. Ybañez is a distinguished Philippine researcher, professor VI at Cebu Technological University, and former Vice-President for Research and Development, leading the Institute for Molecular Genetics, Parasitology, and Vector-borne Diseases (IMGPVBD). His expertise spans veterinary medicine, parasitology, microbiology, vector-borne diseases, molecular biology, phylogenetics, epidemiology, public health, and the social sciences. He earned his Ph.D. in Veterinary Sciences from Obihiro University of Agriculture and Veterinary Medicine in Japan and has accumulated more than 1,800 Google Scholar citations. Recognized among leading Asian and Philippine researchers in the medical and health sciences, he advances work on animal health, infectious diseases, and interdisciplinary approaches. He can be contacted at email: dr.adrianpybanez@gmail.com.



Jennifer B. Carillo is an associate professor I and mathematics educator at Cebu Technological University - Barili Campus, Cagay, Barili, Cebu, Philippines. She is currently a doctoral candidate in the Doctor of Philosophy in Education program, majoring in Mathematics Education at the University of the Philippines Open University. She holds a Master of Arts in Education, major in Mathematics Education, and a Bachelor of Secondary Education, major in Mathematics, from Cebu Normal University. With more than 13 years of experience in tertiary education, her work focuses on mathematics education, curriculum development, assessment in learning, educational technology, and research-based instruction. She can be contacted at email: jennifer.carillo@gws.ctu.edu.ph.



Romeo C. Lepiten is an associate professor and a dedicated academic leader and administrator currently serving as Campus Director of Cebu Technological University (CTU) – Barili Campus. He previously held the position of Campus Director of CTU – Dumanjug Campus, where he played a key role in establishing and strengthening its academic programs and institutional systems. He earned his Bachelor of Science in Electronics and Communications Engineering (BSECE) at the Cebu Institute of Technology–University and later advanced his education with doctoral and management studies, reflecting his deep commitment to academic excellence and professional growth. Over the years, he has held various academic and administrative positions within the CTU system, contributing to policy development, faculty development, and community-engaged learning. He can be contacted at email: romeo.lepiten@ctu.edu.ph.



Rose Mary L. Almacen is the Campus Director of Cebu Technological University (CTU) Danao Campus, a position she has held since 2015, and the former Vice-President for Student Affairs of CTU from 2022 to 2025. As a senior academic administrator and researcher whose core interests encompass Education 4.0, management, construction, science, and applied innovation, she advances indicator systems and pedagogical frameworks to strengthen institutional preparedness, regulatory compliance, and student achievement. Her scholarly contributions include peer-reviewed publications in internationally indexed journals, including sustainability, systems, and frontiers in education, with over 60 citations. At the practice-and-policy level, she has served in various leadership capacities, including Chairperson for Research and Development and Chairperson for Math and Science. She currently leads projects that integrate quality management systems and innovative utility models, such as sustainable material production from agricultural by-products, into the university's strategic growth while spearheading community-based extension programs focused on livelihood, teacher training, and mathematics education. She can be contacted at email: rosemary.almacen@ctu.edu.ph.



Rowena P. Dato-on is a faculty member at the Cebu Technological University Daanbantayan Campus and teaches Statistics and Research subjects. She holds a Doctor of Philosophy in Technology Management and is currently pursuing a Doctor of Development Education. She has a master's degree in Education, both in Mathematics and in Administration and Supervision. Currently, she serves as the Director of Research and Development and Dean of Graduate School Programs at Cebu Technological University Daanbantayan Campus, where she has received recognitions for her academic contributions and mentorship. She is an active member of various professional organizations and regularly attends seminars and workshops in her field of expertise. She can be contacted at email: rowena072669@gmail.com.



Ryan O. Tayco is the Campus Director of Negros Oriental State University (NORSU) Main Campuses I & II and Pamplona Campus, and associate professor V in Hospitality and Tourism Management. An active researcher, he has published numerous articles in hospitality, sustainability, and higher education, building a growing citation impact across regional and international platforms. His leadership extends nationally as Vice President of PHILARM Negros Island Region (NIR), Board Director of PAGE NIR, and Chair of the Resource Generation Committee of Kalambuan Inc., complemented by membership in the National Research Council of the Philippines (NRCP) and other professional organizations. He can be contacted at email: ryantayco@norsu.edu.ph.



Benjamin S. Villagonzalo Jr. is the University Director for Research and Development, formerly the Dean of the College of Business Administration at Negros Oriental State University. He also serves as an associate professor IV and Graduate School Professorial lecturer. A dynamic educator with more than 15 years of teaching experience. He holds a Doctor of Philosophy in Business Administration (Major in Business Management) from the University of Negros Occidental–Recoletos, a Doctor of Business Administration from Saint Paul University Dumaguete, a master's in Business Administration from Foundation University, and a bachelor's in Business Administration major in Management from Silliman University. He can be contacted at email: benjamin.villagonzalo@norsu.edu.ph.



Dawn Iris Calibo-Senit is the research director and an associate professor of Information Technology at Siquijor State College. She holds a Doctor of Information Technology degree from the Technological Institute of the Philippines-Manila, a master's degree in Public Administration, and a master's degree in Science Teaching major in Computer Science, and she has completed academic units toward a Ph.D. in Technological Management. Her scholarly work spans information theory, computer science, data mining, and systems development and design, with three copyrighted software systems registered with the Intellectual Property Office of the Philippines. She can be contacted at email: dawniriscalibo@gmail.com.