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Rural science education during and beyond COVID-19: teachers' strategies and prospects from a Philippine perspective

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ABSTRACT

Distance learning during the COVID-19 pandemic challenged many aspects of the teaching and learning process. However, challenges with the virtual classes were arguably more intense in the rural areas of developing countries, considering technological and socio-geographic limitations. We argue that despite these limitations, rural areas provide opportunities (rural affordances), which may enhance teaching strategies. With the aim of expounding this perspective, we explored science teachers' strategies derived from rural affordances (SDRA) and drawn teachers' perceptions of learners' engagement after the strategies' intervention. Based on the results, three types of SDRA were utilized, namely: contextualization of educational materials for science activities (CEMSA), integration of citizen science in science activities (ICSSA), and integration of traditional knowledge in science activities (ITraKSA), wherein a significant learner engagement with the SDRA are perceived by teachers after the SDRA intervention. Prospects for the utilization of the strategies in post pandemic settings suggest their potential roles in future distance learning schemes as well as in face-to-face learning modality. A paradigm that outlines educational intervention may assimilate the advantages of the SDRA in science teaching. Science education may further communications with policy-makers and stakeholders for a curriculum that drives synergism between rural teaching strategies responsive to pedagogical limitations.

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1. INTRODUCTION

The COVID-19 pandemic has posed challenges and changed the educational landscape in the teaching and learning process. With nearly 1.6 billion learners affected, the pandemic has disrupted the world's educational system and impacted virtually all students (99%) from lower-middle-income countries [1]. The closures of many schools have strained educational systems, especially in places where extended school closures were experienced [2], [3]. The world's governments had to ensure continuous learning, thus immediately facilitating it with educational institutions. Many countries were, however, unprepared for the transition [4], wherein consequences recently surfaced based on the data on learning losses. In the most affected areas (South Asia), an estimate predicts a 25% decline in earnings due to learning losses when students become adults [5]. Even the educational systems of the developed world experienced the trend, such as the learning losses of certain groups of students in Australia [6], Belgium [7], Germany [8], the

Netherlands [9], Switzerland [10], and the United States [11]–[13]. As the negative effects on learning in some areas in developed countries transpired from families or zones with relatively lower incomes, educational challenges are likely more intense in developing countries where lower-income families and regions are primarily represented in the population.

Most of the adverse impacts of COVID-19 on science teaching may be associated with limited or interrupted experiential learning (e.g., suspension of laboratory activities and simulations). Hands-on learning is inherent in developing science skills as learning in an applied environment intensifies learners' engagement and motivates real-life experiences [14], [15]. However, with the goal of continued education amidst the pandemic, science education in many countries had to join the distance learning transitions. The new system delivered virtual methods, which temporarily terminated actual science activities (e.g., laboratory experiments) that supposedly needed experiential operations [16].

The educational challenge also extended to geographical contexts even before the pandemic, as shown by inequality observed in many countries where rural areas are generally disadvantaged in educational outcomes [17]–[19]. With the implementation of distance learning, teaching science became more challenging, considering that science pedagogy in rural areas had limited resources (e.g., laboratory facilities) even before the transition. In the Philippines, the new system faced further difficulties as internet services remain a serious concern in many rural areas where geographical features hinder the expansion of telecommunication networks [20]. Thus, the creativity and resourcefulness of teachers are highly sought in this case, as they have to continue teaching despite these limitations. Instructional resources are inherent to the teaching process [21], and their deficiency may affect instructional outcomes [22]. This shows the need to maximize the teaching and learning process supported by rural settings.

The World Health Organization declared the end of the COVID-19 pandemic as a global health emergency but reminds the public that it is still killing, and possible emerging variants may cause new surges of cases [23]. In this regard, the fate of distance education remains an important issue. As other calamities also hit the country annually, it is necessary to reflect on COVID-19 experiences should other emergencies occur. For instance, schools in Catanduanes Island and other provinces in the Philippines suspended face-to-face classes in April and May 2023 due to heat indices soaring to dangerous levels. The island is also prone to typhoons [24], such as typhoon Goni (super typhoon Rolly) in 2020, the strongest tropical cyclone recorded at landfall based on 1-minute sustained wind [25], [26]. These indicate the possibilities of significant distance learning, albeit with different causes, as a watchlist in future educational systems.

Learning from the rural teachers' strategies during COVID-19 may support and reinforce classroom approaches in current and future settings. In this regard, we explored the teacher's strategies, which we refer to as "strategies derived from rural affordances" (SDRA) in the context of this study. These are instructional strategies (localized lessons) that are done or obtained with rural households (indoor or outdoor premises), backyard gardens, or nearby educational ecosystems (e.g., ponds, meadows), as well as communications or activities with the rural community for science learning. Specifically, we investigated with the following research questions:

i) What are the types of SDRA utilized?
ii) What are the perceived ratings of learners' engagements before and after the SDRA intervention?
iii) What are the prospects for utilization of the SDRA?

2. METHOD

The study was conducted in the rural areas of Catanduanes Island, Philippines. The rural-urban concept was based on the definition by the Philippine Statistics Authority (PSA) [27]. However, in some cases, the information (population, active establishments) on the local areas was still in the updating process (information of ≥2 years ago) or difficult to obtain (e.g., number of employees in an establishment and distance of establishments from the village [>2 km radius] if they are not located within the village's jurisdiction). With these issues, we limited our sampling to rural areas within a distance of ≥3 km from urban centers (11 municipalities) on the island. We then generally sampled the rural areas, excluding those with the abovementioned limitations (also excluding areas with access challenges on terrain or transport systems). We considered a population of 230 teachers where 144 (initial samples) were obtained through simple random sampling, based on the determined sample size from Krejcie and Morgan's table [28].

We conducted a preliminary survey on the prevalence of SDRA use among science teachers, asking whether they utilized or did not utilize the SDRA during distance learning (physical school closures). The survey administration had 95% (137) response/retrieval rates. However, 26 of the 137 teachers either answered that they did not utilize the SDRA (23 individuals) or had provided no information on the activity (blank retrieved questionnaires, three individuals). A total of 111 teachers who used the SDRA were identified, who eventually comprised the study's primary respondents (teachers who utilized the strategies during the COVID-19 pandemic). A total of 65 respondents were from elementary schools, while 46 were from secondary schools. The respondents comprised 90 females (81%) and 21 males (19%). Further, it is important to mention that the population in the study (from which the samples were drawn) is expected to be lower than the actual rural teacher population in the area due to the exclusion of other places, as earlier mentioned.

The survey was guided by a survey-questionnaire, administered anonymously (anonymous survey) and personally (face-to-face with the respondents), including Google Forms utilization. Respondents provided their consent to participate. Surveys were conducted in March-May 2022, August 2022, and May-July 2023. All teachers were teaching science from the start of distance learning until the time of the survey. Science subjects include the general scope (e.g., elementary sciences) to high school sciences (e.g., biology, chemistry, physics/spiral curriculum), including science research subjects. The study intended to include both public and private schools in rural areas. There were, however, no schools in the rural areas that were privately owned during the study.

The questionnaire was content-validated by two master teachers handling science in the province (items for SDRA utilization). During the preliminary survey, many teachers perceived ratings (e.g., 30-50% before engagements, and 80-100% after engagements) which interpretations may be less straightforward with a 1-5 or 1-7 Likert scale. With this concern, we employed a scale of 0-10 (0 as the minimum and 10 as the maximum), with Likert labels of 0% for 0 and 100% for 10. The perceived 0-10 scale (0-100%) is generalized for each class. These rating concepts are subjective only for this study to distinguish differences between the strategies (including the characterizations of engagements [e.g., ≤50% engagements] as described earlier), and not necessarily the exact pattern of the rating systems in their schools.

For the internal consistency of the Likert scales, we calculated Cronbach's alpha (Table 1). Internal consistency reliability indicates how the items are assessed within the same construct or concept. Table 1 shows that Cronbach's alpha generated a 0.87 value (coefficient) with the items on the engagement construct. This is higher than the 0.70 threshold, thus this suggests that the instrument has a high reliability. All statistical analyses in the study were done with SAS-JMP software (11.2.0: Serial No. NHRJ4HJJJZ).

We aimed to identify the type of SDRA used by the teachers and obtain their perceptions of learners' engagement. Perceptions were based on learner engagement before and after the SDRA intervention during modular distance learning (MDL). Our concept of engagements (perceived by teachers) includes the completion of learning modules, guardian narratives, and continuity of communications between teachers and learners (during MDL). The learning module is arranged in a semi-book or booklet form, where learners directly answer or interact on the pages, but they may also use extra sheets or other materials when doing some tasks. A learning module generally has a duration of one or two weeks of the learning process (in some cases, two modules per week or one module per three weeks), but this was subject to flexibility due to the nature of the lesson objectives, the difficulty of retrieval for remote areas, and other prevailing conditions associated with the pandemic.

Table 1. Reliability test (Cronbach's alpha), with the corresponding descriptive statistics

Items on engagement construct (teachers' perception)	Mean	Standard deviation	Cronbach's alpha coefficient
Learners with low MDL engagement before the intervention (MDL alone)	2.96	1.12	
Learners with low MDL engagements after the intervention (MDL with SDRA)	7.78	0.99	
Engagement of all learners before the intervention (MDL alone)	8.36	0.69	0.87
Engagement of all learners after the intervention (MDL with SDRA)	9.06	0.71	
Willingness of all learners to engage in another SDRA after the intervention	9.46	0.63	

Three types of SDRA were identified as: contextualization of educational materials for science activities (CEMSA); integration of citizen science in science activities (ICSSA); and integration of traditional knowledge in science activities (ITraKSA). Typical or "mainstream" science activities, such as experimental, observational, or model-creation activity, are generally included in CEMSA that utilize materials found in the household premises (including open spaces surrounding the house, such as the backyard, front yards, and side yards). This strategy generally works on using physical alternatives when the original materials needed in the lessons are inaccessible or difficult to obtain. ICSSA and ITraKSA, on the other hand, are generally not based on a typical science approach; they are primarily community-integrated science communications or activities that serve as supplementals (or projects) for the lesson. ICSSA mainly involves photo presentations with social media groups/pages or direct communications with science experts, while ITraKSA primarily delivers other science activities that need information from the environment through people's experiences. As the study describes the nature of the rural area and its implication on science learning, descriptions of the area were earlier characterized. In Catanduanes Island, most rural learners (≈90%) live in households with outdoor premises of ≥3 m^2 area, regardless of the socioeconomic status of the occupants (preliminary data). These outdoor sites are usually family gardens or other rural settings, such as meadows, wetlands, and other naturally occurring landscapes.

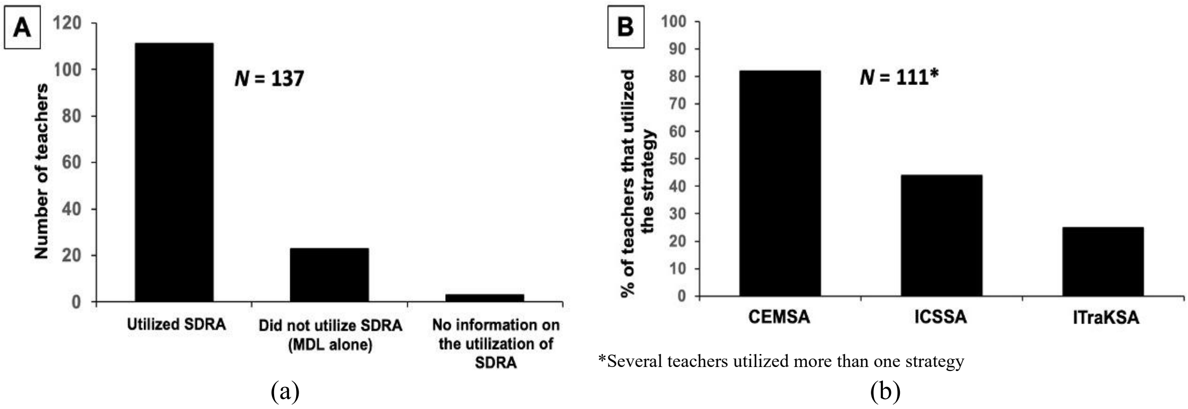
In some parts of the study, perceived engagement was qualitatively characterized (low or high engagements) to provide general comparisons. Teachers perceived low engagements (≤50% MDL engagement) in any or combinations of the following: i) habitual unfinished (≤50% completion) or unanswered modules for the prescribed period; ii) guardian reports of learner disengagements from other tasks; and iii) attempts of withdrawing communications from the teacher (modular concerns) for more than 2-3 months, even during home visits (when home visiting is already allowed). Many teachers generally consider that >50% engagement may be acceptable during the pandemic (others consider >75%). If learners had a ≤50% engagement, a series of post-verification of the learner status, such as communications with guardians and revisiting learner houses (if needed), were conducted by most teachers. For comparisons, engagements are perceived higher (>50%) with the combinations of the following: i) completed modules (written) or at least with >50% completion rate; ii) completed performance report or at least with >50% completion rate; iii) guardian report of learner's enthusiasm on modular works; and iv) learner's reflection of enthusiasm in the activity. Performance reports may be an additional activity (or project), either printed or sent through Facebook Messenger as written narratives, illustrations, drawings, photos, videos, and other modes of performance presentations.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Types of SDRA utilized

Figure 1 presents the types of SDRA utilized, illustrating the 81% utilization rate among teachers (111 out of 137), as shown in Figure 1(a). We identified the SDRA as: CEMSA, which had the highest utilization of 82%, followed by ICSSA and ITraKSA with 44% and 25% utilization, respectively, as shown in Figure 1(b). Teachers utilized the SDRA, guided by the most essential learning competency (MELC) by the Department of Education (DepEd) (main topics and objectives are congruent with the learning modules). Teachers who did not conduct the SDRA believed that the need to use rural alternatives in their classes was negligible at that time or because there were no significant concerns from learners' guardians (of learners' disengagements) about the MDL modality.



*Several teachers utilized more than one strategy

(a) (b)

Figure 1. The SDRA utilization: (a) number of teachers who utilized the SDRA and (b) percentage of teachers that utilized the strategy

3.1.2. Contextualization of educational materials for science activities

This strategy was utilized indoors or at the household's outdoor premises. Teachers believe that rural families generally till or manage outdoor premises, usually for food (e.g., vegetables and fruits), aesthetics (ornamental plants), or both. In several households with larger garden premises, livestock are also raised (e.g., caged or free-range chickens). Many of these household resources were utilized as part of the learning activities, such as the customized food coloring extracted from vegetable leftovers and "specialized" marbles using garden clay or rounded stones (for describing motion). Specific science activities under this scheme included experimentation (e.g., acid-base experiments using fruits or vegetables), pure observation (e.g., observation of plant parts using miniature plants "*plantita*"), and model creation (e.g., soil layer model using kitchen materials). During the earliest phases of the pandemic (roughly 2-3 months after MDL started), teachers utilized CEMSA primarily indoors. Localized experiments such as seed growth of a native plant, natural observations such as rocks observed in the backyard and thermodynamics in the garden, and model creation such as designing a miniature forest in a bowl were examples of experiential learning conducted in the outdoor premises (*homeyards*) setting.

3.1.3. Integration of citizen science in science activities

Rural teachers strategized by engaging their learners in reporting or discussing scientific inquiries with citizen science groups or scientific organizations through social media. For safety, however, teachers instructed that learners must only be within their outdoor premises (e.g., plant photos from the garden) or indoors (e.g., shrimp photos caught by their father from fishing) and share photos or video clips to citizen science groups. Another example of community participation is through photo sharing (on public or private social media groups) of soil, rocks, water bodies, or minerals taken from the outdoor premises. There were general instructions that photo-sharing should be voluntary, where learners can refuse to share them at any time. Some activities during the MDL required descriptions and illustrations of plants and animals in the surroundings. Certain plants or animals, however, may not be readily observed in the area; thus, teachers and learners sought interactions with environmentalists, biodiversity groups, or other science experts. Before the resumption of face-to-face classes, many teachers observed (through home visits) that learners involved with this strategy became enthusiastic about environmental information and would voluntarily engage in conversation about conservation.

3.1.4. Integration of traditional knowledge in science activities

Several teachers used this strategy when science lessons require investigations of the natural world with environmental and social implications. Activities are primarily conducted through interviews (including Facebook Messenger utilization) and sometimes participatory learning facilitated by parents or guardians (depending on quarantine guidelines, especially when pandemic restrictions are relaxed or lifted). A reflection essay constructed by some learners about the effects of typhoons and monsoons learned from farmers and fishers is an example of this case (e.g., modular activity about weather and climate). Likewise, activities on the healing properties of a grass species (e.g., lessons on local medicinal plants) were utilized. In other contexts, customization of materials or models requires traditional knowledge, such as the construction of simple musical objects needed for sound wave activities, and thus was utilized as part of ITraKSA. Other notable examples are the presence of rare species and the ecosystem cultures (e.g., reforestation, catching practices) learned from the island folks' experiences with the rural environments.

3.1.5. Perceived ratings of learners' engagements before and after the SDRA intervention

The teachers perceived that the learners with low engagement (≤50% engagement) during the MDL had a range of 2-5 (20-50%) (mean=3.16 [31.6%]; SD=1.08) engagement rating before the intervention. After intervention with the SDRA, the perceived engagement rating had a range of 7-9 (70-90%) (mean=8.02 [80.2%]; SD=0.77). The data before and after the intervention significantly differ from each other (t-value [log-transformed]=30.43; DF=110; p<0.01), as seen in Table 2. Considering the average engagements for all learners in the class (including learners with >50% engagements), the perceived engagement rating range was 7-9 (70-90%) (mean=8.54 [85.4%], SD=0.68) before and 8-10 (80-100%) (mean=9.15 [91.5%]; SD=0.58) after the SDRA intervention. Results of the t-test (t-value [log-transformed]=12.52; DF=110; p<0.01) for all learners also revealed a significant difference (Table 2). On the other hand, willingness to engage (in all learners) in the next (consecutive) lesson utilized with SDRA had a high mean value of 9.56 (SD=0.50).

Table 2. Paired t-tests among teachers' perception of learners' engagements during the MDL modality

Learner group	Medium/intervention	Mean	SD	DF	t-value	Sig.
Learners with low MDL engagements	MDL alone	3.16	1.08	110	30.43	0.00**
(≤50% before the SDRA intervention)	MDL with SDRA	8.02	0.77			
All learners	MDL alone	8.54	0.68	110	12.52	0.00**
	MDL with SDRA	9.15	0.58			

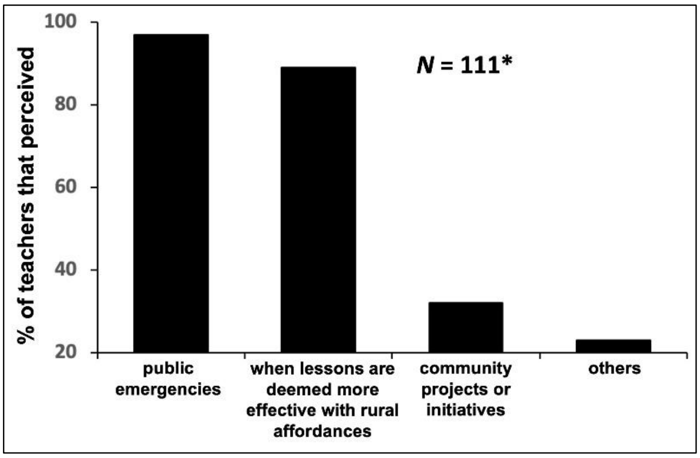
**Significant at the level of 0.01; t-value is obtained from log-transformed data

3.1.6. Prospects for utilization of the SDRA

Different prospects (events or activities) were perceived by teachers when asked about the utilization of the SDRA for future settings, starting school year 2023-2024 (some teachers mentioned that they already started utilizing these prospects in their instructions), as shown in Figure 2. Most teachers (96%)

answered the following events or activities: i) during public emergencies (97%) (e.g., after a typhoon); ii) in cases where rural landscapes and community immersion are deemed necessary for the classroom lesson (e.g., observation in a meadow ecosystem) (89%); iii) when the community, government or non-government organizations request educational activities (e.g., community research projects) (32%), and iv) other specific reasons (e.g., personal initiatives of parents in engaging their children) (23%) (several teachers had two or more answers). They, nonetheless, believe that the enhanced or full implementation of the strategies may depend on the departmental policies and guidelines of face-to-face instruction.

Most teachers desire to integrate the SDRA into classroom instructions (current face-to-face classes). Several of them, however, may not have an active integration (relative to their integration during the pandemic restrictions) because they perceive that classrooms (at present) also meet the lesson objectives or because most lessons are mostly designed within the school facilities and premises. Nonetheless, they may conduct them when they perceive that lesson objectives are more achievable in out-of-school settings.



*Several teachers had two or more answers

Figure 2. Prospects for utilization of the SDRA (events or activities where the SDRA may be utilized)

3.2. Discussion

3.2.1. Utilization of the SDRA

Most teachers considered that learners' disengagement with MDL was significant during the earliest stages of its implementation. Thus, they introduced the SDRA, together with the modular activities. Results show that teachers utilized varied types of SDRA based on the available resources and conditions in the areas. The CEMSA had the highest utilization, perhaps due to the immediate availability of materials and settings in their homes (including home yards) that provide outright learning environments. Further, both ICSSA and ITraKSA may provide additional options, which may be delivered when teachers extend strategies with science communications in the area.

Based on the definitions set in the learning delivery modalities by DepEd [29], all teachers had the MDL modality (including the initially surveyed population) from the start of 2020 distance learning (physical school closures). However, there were instances when materials required in MDL were generally unavailable in many rural households, especially those in remote communities (hamlets). In these regards, alternative local resources for the learners (and guardians) were utilized, probably due to the significance and practicality of using resources from rural areas.

3.2.2. Contextualizing in the local setting

Rural areas have natural advantages in providing educational resources, such as nearby ecosystems (e.g., meadows) in the community [30]. However, the utilization of these advantages was affected during the isolation of communities due to lockdowns. As the quarantine rules gradually eased, teaching strategies had to adapt as well (many teachers worried for the safety of their learners during heightened restrictions; thus, their earlier activities were mainly indoors). The subsiding restrictions (through quarantine scheme announcements) likely provided opportunities for utilizing the outdoor premises (learning modules generally permit activities on household premises, including backyard areas), which could be advantageous for the learners. For example, young learners are comfortable learning outdoors as they are their natural playing grounds [31]. Thus, learning with the outdoor spaces could be meaningful and facilitating for them.

Out-of-classroom activities remove the physical constraints of the classroom [32], delivering a contextualized and flexible learning system.

Gardens have educational purposes, not just for plant knowledge but also for animals and other scientific processes associated with botanical development [33]. In this context, the household setting on the island may serve as easy access for learning due to the family's daily routine of tilling or managing the land. This potentially makes rural learners generally familiar with outdoor premises-related activities due to these skills. However, comparing learners in rural and urban areas regarding science-based works (on household premises) is beyond the study's scope.

Utilization of this affordance can be viewed as highly advantageous especially when some pedagogical methods are limited (such as during COVID-19 restrictions). This concept of learning in the outdoor environment is not new to Philippine education, such as the school garden program by DepEd [34]. However, this concept of outdoor learning was arguably intensively applied by teachers during the pandemic, demonstrating the evolving strategic development during out-of-school teaching schemes.

3.2.3. Engaging learners with citizen science

Citizen science is a system where volunteers participate in a project, usually associated with academic or research bodies [35], [36]. It is an interdisciplinary field, whose scopes may overlap across various disciplines, including education. There has been a growing interest in the role of citizen science in education in line with the expanding scientific and environmental knowledge [37], [38].

Considering that a large portion of research activities of citizen science are in biology and conservation [39], [40], the presence of natural landscapes in rural zones of Catanduanes Island (e.g., meadows and hills), including tidal flats [41] and other island ecosystems [42]–[44] may enhance the establishment of many citizen science groups in the community. Through this, the science teachers had opportunities to engage their learners with citizen science using social media. However, one immediate concern is the area's limited internet connections. Nevertheless, since learners can get involved later in the day (when an internet connection becomes possible), this became applicable and achievable for many learners.

The interactions with environmentalists, biodiversity groups, or science experts may facilitate learners' engagement in biodiversity monitoring and other citizen science activities, thus delivering an exploratory medium for science learners. The role of citizen science is argued on its potentially significant contribution to education [45]–[48], providing synergism between pedagogy and science. Perhaps, one of the most notable features of the citizen science approach to science pedagogy is enabling the learner's interest in science and environmental conservation. These indicate a potential impact of citizen science integration in science education.

3.2.4. Incorporating traditional knowledge

Traditional knowledge is defined as a body of facts developed and maintained by distinct cultural groups (as a result of direct observation and practice) with extended histories of interaction with the natural environment [49]. As learning integration implies efficiency in addressing 21st century competencies [50], this may provide opportunities for teachers to utilize the strategy as reinforcement, especially when educational resources are limited. This may be viewed as advantageous in rural areas. While communications with folks about environmental and natural knowledge are also possible in urban settings, it is probably more facilitating in rural areas due to people's experiences with natural ecosystems and rural mobility without a general need for transportation and complicated logistics.

In Catanduanes Island, most rural families are engaged in farming, fishing, or both (unpublished data). For community reference, many of these environment-engaged persons would visit the house of their friends or family members. It has been known that many rural communities have stronger social bonds, which are enhanced through frequent communication and participation in activities within the community [51]–[53]. This scheme may have provided an opportunity for furthering the strategies in the rural setting, capturing the input of indigenous communication in science teaching and learning. As learning with folks is highly localized (in which many aspects might not be explored in typical classroom instructions), it may facilitate a meaningful knowledge transfer, while cultural identity is embodied among rural learners.

3.2.5. Perceived intervention outcomes

Results reveal that teachers perceived an increase in engagement with the intervention (during the MDL), showing that even those learners with low engagement (≤50% before the intervention) had a higher engagement rating after the intervention. The perceived increase in engagement (including those with low engagements before the intervention [≤50%]), suggests that the science teaching and learning process keeps changing, considering the integration of localized strategies. Additionally, the learners' willingness to engage in the next (consecutive) SDRA may reflect positive acceptance. This corresponds with the evolving strategies associated with the COVID-19 pandemic, and future disasters [54], [55]. As teachers perceived that the SDRA significantly increased learners' engagement, this suggests the potential positive impact of the intervention on science learning. In this regard, discussions may be necessary for future communications with the Philippine academic authorities, especially on SDRA integration with face-to-face classes. It is to emphasize, however, that this does not attempt to establish SDRA as a replacement for face-to-face classroom activities in the area but intends to diversify the teaching and learning process with localized reinforcements.

3.2.6. Future directions for the application of the SDRA

Public emergencies were mostly mentioned, probably due to teachers' experiences with typhoons, which are linked with the cancellation of classes during typhoon season on the island. This may also be true with other phenomena, such as the recent suspension of face-to-face classes in Catanduanes (April-May, 2023) due to heat index advisories. This further implies that the "classroom at home" may be repeated. The "heat index" suspension is relatively uncommon in the province, but considering the dynamic environment, class suspension related to this may become more anticipated. Similarly, as vulnerabilities from tropical cyclones are generally known in Catanduanes Island [24], integration of the strategies may be anchored with other policies concerning class suspension when classroom facilities are still recovering from the typhoon aftermath. For example, typhoon Goni (super typhoon Rolly) in 2020 severely damaged many schools on the island [56]. Due to the typhoon damages, resuming face-to-face classes might have taken several weeks or months (if, for instance, there was no pandemic-driven school closure) at that time.

The condition may provide more chances to utilize the natural spaces as the community becomes more eased and relaxed after COVID-19 restrictions. It has been viewed that nature experiences (outdoor premises, including community-based affordances) provide increasing ecological knowledge and a pro-environmental mindset [57], hence the pedagogical advantage. Moreover, the perceived alternatives (SDRA activities) are potential opportunities from rural zones even when face-to-face classes are already in effect. Rural areas may also provide other specialized schemes in a lesson, such as specific activities for skilled learners (including cases when parents personally request an outdoor engagement for their children). Nonetheless, this may need regular monitoring and assessments, which may be delved deeper in future studies. Further, the desire to conduct the SDRA (when they believe that a lesson objective may be fully achieved in out-of-school settings) may be limited in face-to-face classes as instructions are primarily conducted in the classrooms. Therefore, the fate of enhanced integration of the strategies in rural zones may depend on the provisions and guidelines of the Philippine educational system in the post-pandemic era.

4. CONCLUSION

Rural science teachers utilized the SDRA (CEMSA, ICSSA, and ITraKSA) to facilitate the teaching-learning process, wherein they perceived higher learner engagement after the SDRA intervention. This suggests a potential reinforcement role of the SDRA during distance learning, which may be incorporated into future distance learning schemes (e.g., calamity-mitigated educational programs, other pandemics). Further, the strategies are also prospected to be utilized in face-to-face instructions, signifying their probable roles in post-pandemic settings. An educational paradigm that addresses these issues may be necessary to assimilate the advantages of the SDRA in science teaching. Science education in the area may then rely on policy-makers and stakeholder communications for a curriculum that drives synergism between teaching strategies responsive to pedagogical challenges.

We acknowledge that perceived learners' engagement may pose subjectivity, considering teachers' skills (estimating averages), personal experiences, and expectations. As the data on learners' activities were drawn from the pooled observations (perceptions) and not from individual assessments, these may not capture some traits of learners, hence the possibility of certain attributes deviating from the findings. Objective testing of individual learners' activities on each SDRA is recommended, preferably with larger samples across the Philippine countryside (including conducting qualitative investigations), to elucidate multi-faceted perspectives and mitigate potential biases.

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C : **C**onceptualization
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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 state no conflict of interest.

INFORMED CONSENT

Informed consent was obtained from all individuals included in this study.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author [KQA], upon request.

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