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Developing Conceptual and Procedural Knowledge/Skills of Lifelong Learners from Basic to Advance Learning: Exemplars, Challenges and Future Direction

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ABSTRACT

Developing conceptual and procedural knowledge or skills of learners is 'part and parcel' of the roles of educators involved in teaching science and social science subjects. This article aims to espouse numerous educational reforms implemented locally, regionally, and internationally during the past decades, with exemplars and challenges elaborated. The mixed-method approach is selected as a research framework that includes the collection of qualitative data (mainly from documentary analysis, interviews, observation, and open-ended responses) and quantitative data (mainly from survey questionnaires). This article reports mainly qualitative findings that are summarised from mixed-modes of analysis on data collected through systematic review and 'multiple-case design', including 'cross-case and within-case analysis' on how conceptual and procedural knowledge and skills of learners could be enhanced through the implementation of various technology-integrated project-based programmes incorporating various effective strategies anchored on hybrid approaches in replacement of traditional methods. Case exemplars are illustrated with how these programmes served as platforms for basic education and foundation courses from basic to advanced learning among lifelong learners. The analysis of a local programme to promote Year 4 students' (N = 33) primary science learning using the 5E constructivist model revealed that students were mentally engaged in learning science concepts, interacting with new experiences, and able to correct misconceptions with enhanced conceptual and procedural knowledge and skills on the taught topics 'Scientific Skills, Life Processes of Humans and Properties of Materials' as reflected in their increased mean scores of science achievement analysed statistically. The implementation of the 'Learning Science and Mathematics Together' (LeSMaT) student-centered regional learning program that provided a guide for expected project output is also illustrated with an exemplar of how learners' conceptual and procedural knowledge and skills in 'environmental education' were enhanced through the preparation of the project required for this program. The analysis of social science learning involving building foundation knowledge on economics through an international research-based internship program revealed that students' conceptual and procedural knowledge and skills in 'economics' was enhanced with the input on research methodology and the need to produce a report, which tied with theories and the experience of their placements in various business settings that provided real-life experience related to economic issues faced during the pandemic. In conclusion, the significance and implications of the study are deliberated with suggestions for the way forward.

Keywords: conceptual or declarative knowledge, procedural knowledge or skill, basic education, foundation course, science/social science studies, mixed-research multiple case analysis

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INTRODUCTION

Background and Overview

Teaching science and social science subjects with the development of conceptual and procedural knowledge or skills among learners is 'part and parcel' of the role of educators. Learners need to build adequate basic knowledge before they can proceed with learning concepts related to their aspired fields of studies, e.g. engineering or health education for students in science streams, and economics or accountancy for those who want to pursue careers related to arts streams. However, questions were always raised as to whether the conceptual or procedural approach should be given more priority or emphasis. Also which of these approaches should come first to groom a better learner? Some are not highly or uneducated people with good procedural skills who could carry out daily activities such as cooking, operating a machine, or even inventing something new as a technopreneur. Could they be better equipped with conceptual knowledge (i.e. understanding what they are doing or the scientific principles behind these actions) and able to disseminate their findings?

Numerous efforts have been made over the past few decades to support quality basic education and foundation courses that are offered to provide platforms for the advancement of science and social science studies using various approaches, from policy implementation to practise in educational settings. For example, among the SEAMEO's Education Agenda that reflect 'leading through learning', priority area No. 7 was set to promote a radical reform through systematic analysis of knowledge, skills and values needed to respond to changing global contexts effectively [1]. For example, priority area No. 7 of the SEAMEO's Education Agenda, which reflects 'leading through learning,' was established to promote radical reform through systematic analysis of the knowledge, skills, and values required to respond effectively to changing global contexts [1].

This article aims at espousing the various reforms made over the past decades with a showcase of exemplars, elaboration on challenges, and suggestions for the way forward for project-based programmes and modular approaches aimed at developing conceptual and procedural knowledge and skills of lifelong learners from basic to advanced learning.

Review of Related Literature

Conceptual and Procedural Knowledge/Skills Required in Basic Education Anchored on Constructivist Framework

'Conceptual knowledge' is the 'understanding of why we are doing an action' or the 'understanding of the concepts in order to solve certain problems'. In a more elaborative manner, 'conceptual knowledge' (or sometimes being referred to as 'declarative knowledge') refers to the understanding or knowledge of aspects such as classification of living/non-living things, concepts, laws, models, principles and theories. This type of knowledge is acquired through experience, listening, observation, reading and deliberate or reflective mental activities. However, according to [2], a conceptual approach could be highly structural based, and require minimal equipment for hands-on activities that are designed to let students use their own logical reasoning and be engaged in learning mathematics conceptually without knowing the procedures to be followed.

On the contrary, 'procedural knowledge' is operationally defined as 'knowing what to do' and involves the 'working out of any procedure that can be used to solve certain problems', regardless of whether the problem solver may or may not understand the reasoning behind a procedure. An example, according to A to Z teacher Stuff, was that many students were found to have not mastered the conceptual understanding 'fractions' with long-term memory, but they could solve the problem related to 'fraction' as they memorised a procedure just for the sake of an exam or test [3].

A conceptual approach is referred to as something more directed, explicit, and prescriptive. Whereas the constructivist approach promotes 'learning through self-initiated, practical exploration, such as the Montessori method, which that is based on the principle of constructivism, i.e. a description of the process by which we have the task of learning anything of real importance, i.e. something we have an actual need for, a self-directed/self-paced learning-by-doing path is initiated to master that skill. For example, learning to master the art of gardening, painting a portrait, learning to sew, to name a few [2]. In fact, there are many variations of constructivism, or active learning, including experiential learning, discovery learning, and knowledge development.

Over the years, there have been various models developed anchored on the constructivist model, and 5E is one of the constructivist models developed by Bybee in 1997, involving 5 phases, i.e. 'Engagement, Exploration, Explanation, Elaboration, and Evaluation'. Each phase has specific functions that contribute to the teacher's coherent instruction and better students' conceptual understanding of scientific and technological knowledge [4][5]. To wrap up the achievement of the lesson objectives, the teacher can observe the engagement and students understanding through continuous observation during the lesson. The 5E constructivist model is widely used because it proves that people build knowledge and meaning from experience. In the educational context, the 5E model gives students the opportunity to engage in learning with peers while exploring their own knowledge either through doing projects, experiments, inventions etc [6]. Minimal supervision from a teacher gives freedom to students to create, express themselves and use their optimal "energy" to explore and elaborate. Furthermore, it also increases their understanding of concepts or facts that will be used in life. In acquiring self-knowledge, students also need to make a refinement of newly learned knowledge, i.e., combine it with previous knowledge in reforming a solid understanding of concepts or facts, especially in science. In addition, this 5E model can unearth students' talents in communicating to convey opinions or findings so that they can be shared with classmates, s a result, making learning alive and conducive environments.

Basic Education as Foundation for Lifelong Learning in Sustainable Future

According to Article 1.4 of UNESCO, basic education is defined as the development of attitudes, values, knowledge and competencies [7],as the foundation for lifelong learning and human development of which any country may systematically build further levels on numerous types of education and training [8].

A *foundation course* is normally taken at tertiary institutions such as centres, colleges and universities, as a year-long introductory programme. The course/programme can be in the form of either a wide range of subjects or only as per subject at a basic level that aims at preparing students for a more advanced level of study [9] in a new environment. Students are also prepared to attain the correct level of qualifications, skills, knowledge and confidence to pursue, for example, a fully-fledged (normally 3 years) undergraduate degree at university with additional English language support as a basic requirement of the course and to fulfil their maximum potential in their studies. Literature also revealed foundation years are crucial to assist international learners to adapt themselves in academic and lifestyle of other dissimilar countries. An additional year spent on the foundation course is a superb technique for those late bloomers/developers to get into a higher level of studies. [10][11].

Problem Statement and Rationale

Education is an essential requirement along with other basic needs to have a good quality of life for anyone in anywhere. In developing countries especially in the South Asia region, basic education is pivotal to eradicate poverty, minimize inequity and steer economic development [10]. However, there had been ongoing debates about the suitable types and effective strategies to implement basic education with minimum disparities and inequalities among the global population especially in countries scattered in the far-flung areas of each continent such as the SEAMEO region. Mathematics has long been considered one of the important topics introduced in basic education for lifelong learners and foundation course for school going students to pursue an advanced level of studies whether in both science or arts-based subjects such as health education, engineering, accountancy, economics, to name a few.

Nevertheless, there has been long-running arguments about whether teaching mathematics in a conceptual way is superior than teaching this subject using the procedural method. Such arguments had caused the mathematics educators to be divided into two opposite sides in the US particularly, i.e. the proceduralists vs. the conceptualists. The debates from each side have inclined to be contradictory. For example, there was the argument of traditionalists who claimed that progressionists only cared if students comprehend concepts but were uninterested if they can actually solve math problems [2].

In addition, there were also arguments that many of the professional learning programmes which recommended the shift towards conceptual approach seldom gave their participants adequate and self-explanatory guide or clear roadmap to implement a conceptual approach. There were suggestions that mathematical understanding among students could be fostered through using activities and strategies that could allow students to participate in hands-on/minds-on activities early in the unit before the introduction of procedures, preferably through a hybrid approach that includes both conceptual and procedural approaches with 9 keys recommended. A hybrid approach includes the essential prerequisites from both approaches, i.e. the 'students are enabled to understand what it is they are working on in the class (quality conceptual approach) and the explicit teaching of procedures (quality procedural approach). This hybrid approach is mainly student-centred with a highly-structured conceptually-based approach also incorporates the explicit teaching of procedures preferably implemented using department/system-wide or team-based -wide approach [2].

One factor of teacher failure in the classroom is the inadequacy of the teaching approach which makes students feel bored, drowsy and tired [1]. In addition, effective teaching and learning approach should be able to challenge student abilities as well as develop the creative and critical mind of students through planned and innovative teaching approaches such as active and student-centred learning approaches such as project-based activities or 5E modular approach with tracking/monitoring and sharing of exemplars. 5E constructivist model is an example promoting hybrid approach as it consists of authentic student engagement that enhances conceptual and procedural knowledge/skills, let them immerse in activities with a thorough understanding of what they are working on with ownership of learning [2]. These approaches could possibly enhance both conceptual and procedural knowledge/skills of lifelong learners with a better foundation in a core subject such as mathematics.

Aim and Research Question

This paper aims to examine if the implementation of values-driven project-based programmes could possibly replace the traditional approach to provide a platform for a hybrid approach to developing conceptual and procedural knowledge/skills of lifelong learners from basic to advanced learning. The evolution of these types of programmes that were implemented in the past decades is analysed including numerous approaches/strategies that were implemented incorporating conceptual and procedural knowledge/skills in foundation courses.

The following are the research questions as a guide for this study:

1) How could the implementation of project-based programmes enhance conceptual and procedural knowledge/skills of lifelong learners?
2) What are the strategies/approaches and challenges faced to develop conceptual and procedural knowledge/skills of learners sustainably from basic to advanced levels of education?
3) Are there exemplar(s) of values-based programmes implemented locally/regionally/internationally that could illustrate the integration of conceptual and procedural knowledge/skills for lifelong learners?

MATERIAL AND METHODS

This paper examines how conceptual and procedural knowledge/skills of learners could be enhanced through the implementation of various technology-integrated project-based programmes that serve as a platform for foundation studies with various effective strategies anchoring on hybrid approaches in replacement of traditional approaches. Mixed-method or multimethod approach [12] is selected as the research framework of this study. These include the collection of qualitative data (mainly from documentary analysis, interviews, observation and open-ended responses) and quantitative data (mainly from survey questionnaires). The presentation of findings are mainly from a mixed-mode of analysis on data collected through systematic review [2] and 'multiple-case design' [13] to overcome the issue of generalizability just based on a single case study, also to corroborate the evidence that enhances the validity of study [14].

The selection of literature or articles (that are relevant to the Research Questions) through systematic review on various databases involving synthesis and evaluation of all accessible evidence was first conducted with findings summarized in tables. Numerous studies published in peer-reviewed e-journals, e-books/databases between 2010 to 2021 were explored through Search Engines such as Google Scholar, the International Journal of Computer Applications (IJCA), Research Gate and Scopus, to name a few. The keywords or topics explored included 'project-based programmes, foundation studies, transdisciplinary approach, STEM, STEAM, computational thinking, robotics, to name a few.

In this study, there are two main types of multiple-case analysis [15] i.e. Cross Case Analysis' (CCA) that looked for common patterns between using the characteristics/elements of programmes that enhance conceptual/procedural knowledge/skills and integration mechanisms of strategies/approaches in foundation studies; as well as 'Within-Case Analysis' (WCA) that looked separately at each specific case of how values-based programmes implemented locally/regionally/internationally could integrate conceptual and procedural knowledge/skills enhancement for lifelong learners.

Hence the aforementioned research methods are concurred with the five purposes of mixed-method research reported by [16] i.e. (1) complementarity to clarify the result of a single method; (2) development as it helped one method to shape another; (3) expansion that provided a richness of study through multimethod approach; (4) initiation with the formulation of new research questions; (5) triangulation that serves as finding consistency of the study with enhanced breadth and depth

RESULTS AND DISCUSSION

This section provides discussions of the results with elaboration based on analysis of findings.

Implementation of Programmes that Enhance Conceptual and Procedural Knowledge/Skills

Table 1 summarizes the cross-case analysis of project-based programmes implemented from 2010-2015 and 2016-2021 locally (e.g STEM/STEAM-based modular approaches), regionally (e.g. SSYS, MAAYS), internationally (e.g. LeSMaT and R-CBL) and locally (e.g. Teacher Education Institute).

Table 1. Cross-Case Analysis on Implementation of Programmes to Enhance Procedural and Conceptual Knowledge/Skills

6-Years'	2010 to 2015		2016 to 2021	
period (**Institution based**)	Regional Centre	Community-based	Regional Centre & International School	Institution/ University-linked
Project-based programme implemented locally, regionally and internationally	'Search for SEAMEO Young Scientists' (SSYS) [17] forum supporting 'Learning Science and Mathematics' in a Borderless World' [LeSMaT (Borderless)]	'Malaysian Academy for Advancement of Young Scientists' (MAAYS) hyperlinked to SEARCH portal [18]	LeSMaT(Borderless) offshoot LearnT-SMArET programme in support of Teacher Training Institute (TTI) [19]	STEM/STEAM-based Modular and student's autonomous learning approaches and 'Robotics Competition-based Learning' (CBL) [20] [21][22]
Lifelong learners and target groups	School teachers and students in 10 SEA countries	Teachers and students local and abroad.	School teachers and students in 11 countries & beyond	Student teachers who are training school going students [19].
Strategies/approaches and policy/ operational planning	Five-year development and strategic plans were prepared for each phase of R&D	State Government supported programme in collaboration	Five-year development and strategic plans were prepared for each phase of R&D	5E constructivist approaches for STEM education [18]; Autonomous learning emphasizing learners'

6-Years'	2010 to 2015		2016 to 2021	
period (**Institution based**)	Regional Centre	Community-based	Regional Centre & International School	Institution/ University-linked
	activities involving SSYS [17] and LeSMaT regional programmes.	with SEAMEO regional centre	activities involving SSYS [17] and LeSMaT regional programmes.	voice [19]; independent laboratory practical.
Monitoring, evaluation as well as research and development activities	An online learning hub in SEARCH for youth science and mathematics researchers [20] as well as other hyperlinks websites and e-forums.	E-forum hosted in MAAYS portal with interactive discussions among experts	An online learning hub in SEARCH for youth science and mathematics researchers [18] as well as other hyperlinks websites and e-forums.	Analysing students' project output, reflective journal and practical work. [20]
Information and Communication Technology (ICT) integration	Website and social learning platforms for LeSMaT (Borderless) [23]	E-learning portal [18] hyperlinked to SEARCH	Website and social learning platforms for LeSMaT (Borderless) [23]	Use of digital tools and e-platforms [19]

Strategies/Approaches and Challenges in Foundation Studies for Sustainable Future of Lifelong Learners

Table 2 summarizes the cross-case analysis on strategies/approaches and challenges in basic education or foundation studies for sustainable future of lifelong learners for the project-based programmes implemented at or led by regional centre, community, international school and university from 2010 to 2015 and from 2016 to 2021. Among the exemplars included 'Search for SEAMEO Young Scientists' (SSYS), 'Socio-scientific Issues' (SSI) lesson exemplars following 'Analyze, Design, Develop, Implement and Evaluate' (ADDIE) instructional design model, LeSMaT (Borderless), Robotics Competition-based Learning (R-CBL), to name a few.

Table 2. Cross-Case Analysis on Strategies/Approaches and Challenges in Basic Education or Foundation Studies for Sustainable Future of Lifelong Learners

6-Years'	2010 to 2015		2016 to 2021	
period (**Institution based**)	Regional Centre	Community-based	Regional Centre & International School	University-linked
Project-based programme (with differentiation of instruction and expected output as a natural by-product of student-centred approach) implemented locally, regionally and internationally	'Search for SEAMEO Young Scientists'(SSYS) forum supporting 'Learning Science and Mathematics' in a Borderless World' [LeSMaT (Borderless)] [24] [26]	'Malaysian Academy for Advancement of Young Scientists' (MAAYS) hyperlinked to SEARCH portal [20]	LeSMaT(Borderless) offshoot LearnT-SMArET programme in support of Teacher Training Institute (TTI) [21]	STEM/STEAM-based Modular Approaches and 'Robotics Competition-based Learning' (R-CBL)[23][24]
Challenges faced during implementation	To implement blended learning for a wider audience in the far-flung SEAMEO region.	Accessibility to Internet and wifi connection	To reach out to all 11 SEAMEO member countries including those with digital divide to access ICT [26].	Teachers as facilitators should guide students' independent learning well [23]
Conceptual knowledge (including	SEAMEO delegates participated in	PBA modular approach in	Building foundation knowledge on	STEM-focused learning promoted

6-Years' period (**Institution based**)	2010 to 2015		2016 to 2021	
	Regional Centre	Community-based	Regional Centre & International School	University-linked
metacognitive, HOT, computational thinking) skills enhancement integrating values	values-based hybrid mode self-paced/self-directed /self-access learning of science/maths [23][24]	teaching scientific investigation integrating values [25][26]	economics through international research-based internship programme [25][26]	computational thinking skills [19][20]
Procedural knowledge (including research) skills enhancement	Guidelines for investigative project informed a year before the event. [17][27]	Participation of students in SSYS project presentation. [17][27]	Project guide with input on research skills through e-survey in G-forms [26][27]	Students' investigative project output, and practical work.
Life (entrepreneurial/ survival/work/ communication/ collaborative) skills enhancement integrating values	SSYS biennially held event as platform for life skill enhancement integrating values [17][25][27]	Local student networking with international delegates [25][26]	Development of life (entrepreneurial/ work) skills during internship placement [8][25]	Students' reflections and STEM output [13] promoted communication skills and technopreneurship skill
Technology skills enhancement	Website and social learning platforms for LeSMaT (Borderless) [27][28]	Computer literacy enhancement [27][28]	Website and social learning platforms for LeSMaT (Borderless) [27][28]	STEM [18] integration supported by the use of digital tools and e-platforms.

Exemplars that Illustrate the Integration of Conceptual/Procedural Knowledge/Skills in Foundation Studies

Table 3 summarizes the within-case analysis on exemplars from selected project-based programmes implemented locally, regionally and internationally for the past 5 years.

Table 3. Within-Case Analysis on Exemplars from Selected Project-based Programme(s) Implemented Locally, Regionally and Internationally

Exemplars	Approaches/Strategies		Skills (values-driven) Integration in Foundation Studies			
	Transdisciplinary	System wide	Conceptual	Procedural	Life	Technology
SSYS forum supporting LeSMaT (Borderless)	Learning output reflecting conceptual/ procedural knowledge/ skills (e.g. investigative project) [25]	Regionally in blended-mode	Scientific (experimenting/ investigating) & Higher order thinking (HOT) (critical/ creative)	Application of science concepts (e.g. Chemistry) in daily life (to combat pollution, etc)	Communication skills to prepare research/project proposal/report, record data, disseminate findings, etc.	Application of conceptual / procedural knowledge in investigative research via e-platforms
From MAAYS in SEARCH for youth researchers to Vision Academy and Life Rhythm	Support of human resource development through e-learning	Regionally in blended-mode	Project-based activities (PBA) module integrating values [31][32][33]	Problem-solving, investigation skills	Values-driven, life (work) and communication skills	Project-based learning (PBL) integrating ICT [17]
LeSMaT(Borderless) offshoot LearnT-SMArET programme in	Learners' output integrating transdisciplinary studies in LearnT-SMArET	Internationally in blended-mode	Scientific, HOT and problem-solving skills (PBS) during	Application of environmental science	Communication skills to prepare research/ project	Application of science conceptual knowledge using

Exemplars	Approaches/Strategies		Skills (values-driven) Integration in Foundation Studies			
	Transdisciplinary	System wide	Conceptual	Procedural	Life	Technology
support of TTI and SIT	online course series [30]		PBA and problem-based learning (PBL)	in daily life with conservation of resources	proposal/report, documentation, record data, publishing, etc.	digital tools e.g. Augmented Reality (AR)
STEM/STEAM/SSI issue-based Modular Approaches	STEM module using 5E constructivist model [32]	Locally in blended-mode	STEM to STEAM and CT skills [23][24]	5E constructivist model as guide	STEM focus curriculum proomote sustainable living	STEM-based design learning enhance students' technology skill [33][34]
'Robotics Competition-based Learning' (R-CBL)	R-CBL module anchoring on constructivist model [19].	Internationally in blended-mode	Science (e.g. Physics) Learning and Computational thinking (CT) skills [21][22]	Research and Robotics competition-based learning (R-CBL) [19].	Values-driven, life (entrepreneurial/ survival/work) skills [35][36][37]	The application of science in solving real life problems

The following Table 4 illustrates an exemplar from STEM-based Modular approach to teach primary science in rural areas using the 5E constructivist model

Table 4. Exemplar from STEM-based Modular Approach to Teach Primary Science in Rural Areas using 5E Constructivist Model

No	**Phase**	**Observation findings during tryout of modules related to development of conceptual and procedural knowledge/skills**	**Sample illustrations**
1	Engagement	• The teacher was found to have stimulated students to draw their attention, involving in the learning process and make connections between past and present learning experiences through varied interesting and meaningful activities; • Where the teacher raised questions concerning the pre-defined problem, the students revealed their ideas and beliefs. • Students' ideas were compared, they were let work individually or in cooperative groups, hence they became mentally engaged in the concept, process, or skill to be learned on a primary science topic.	
2	Exploration	• The students were found to interact with new experiences that arouse many questions that may be difficult to answer. • By doing activities, they tried to find an answer to these questions which will lead ~~that will~~ lead them to discover relationships that were not known to them before. • The teacher was seen to play the role as guide, facilitator and advisor. He/she gave encouragement and training to enhance students' procedural skills to continue activities until the clear image of scientific concept become apparent.	

No	Phase	Observation findings during tryout of modules related to development of conceptual and procedural knowledge/skills	Sample illustrations
3	Explanation	• The students were seen to have benefitted from the results of the previous two phases where they could correct their misconception on the concept. • The teacher was seen to collect information from students to help them in organizing, summarizing and processing it mentally until the concepts, operations, & skills become understandable and clear. • Then student, at this stage reach the new ideas offered by the teacher and has the ability to re-formulate these ideas in a scientific manner, with the teacher starting to draw and connect the student's conceptual understanding. • Interpretations with these experiences were facilitated by the teacher to make sure that the students were able to interpret the exploratory experiments using scientific terms correctly.	
4	Elaboration	• The teacher was seen to challenge and extend students' conceptual understanding and skills. • Through new experiences, the students developed a deeper and broader understanding of e.g. the effect of adding some amounts of soda bicarbonate to the increasing of the size of balloons, more information, and adequate skills. • Students applied their understanding of the concept by conducting additional activities.	
5	Evaluation	• Students received feedback on the adequacy of their explanations and abilities. • Informal evaluation occurred from the beginning of the instructional sequence. • An on-going diagnostic process was seen that allowed the teacher to determine if the learners have attained an understanding of concepts and knowledge. • Evaluation and assessment occurred at all points along the continuum of the instructional process. Some of the tools that assist in this diagnostic process are: (a) Rubrics (quantified and prioritized outcome expectations) that were determined hand-in-hand with the lesson design. (b) Teacher observation was structured by checklists, student interviews, portfolios designed with specific purposes, project/ problem-based learning products, and embedded assessments.	

(Adapted from [14][16][18][20][21]).

CONCLUSION

Significance and Implications

In this study, numerous educational reforms implemented locally, regionally and internationally during the past decades were espoused with exemplars and challenges elaborated through cross-case and within-case analysis on how the project-based programmes served as blended-mode platforms for basic education and foundation courses from basic to advanced learning among lifelong learners. For example, the SSYS biennially held events that were conducted fully on-site were evolved into the blended-mode approach to cater for wider participation and constraints faced during the pandemic. The experience organizing MAAYS programme led by Vision Academy also stimulated further creative venture to promote 'life rhythm'. The management of technology-enhanced innovation programmes was also evolved into a hybrid approach [encompassing inquiry-based science education (IBSE), project-based activities (PBA), problem-based learning

(PBL) and robotics competition-based learning (R-CBL)[19] in which the input from one project-based programme could support the organization of other events as reported by [26].

Another exemplar, 'LearnT-SMArET' online training SEAMEO Education Agenda programme [34] as an offshoot programme of LeSMaT(Borderless) initiative was conducted since 2018 (as summarized in Table 1 and with exemplar reported in Table 3) focusing on different themes and sub-themes set [related to STEM, STEAM, STREAM and transdisciplinary approaches [25]. This programme was also found to be effective in enhancing students' conceptual and procedural knowledge/ skills through STEM-related project-based activities requiring students' submission of technology-enhanced learning output uploaded online. LeSMaT(Borderless) initiative and other SEAMEO TVET programmes had been in support of local/national [e.g. teacher education institute that promoted STEM-based Environmental Education studies and university that promoted computational thinking (CT) as well as financial literacy/entrepreneurial skills urgently required in IR4.0 era] and international (e.g. the programme coordinated by the fourth co-author in her postgraduate studies)[27]. The analysis of social science learning involving building foundation knowledge on economics and financial literacy through an international research-based internship programme revealed that students' conceptual and procedural knowledge/skills on 'economics and international relations' were enhanced with the input on research methodology and the need to produce a report which was tied with theories and the experience of their placements in various business settings. All of these provided real-life experience related to economic issues faced during the pandemic as experienced by the fourth co-author. The building of financial literacy for social science learning is as important as the development of scientific literacy for science learning and the latter was researched and reported [9].

Constraints and Lessons Learnt with Suggestions for the Way Forward

From a systematic review of literature and analysis of cases in this study, it is evident that changing from a traditional procedural approach to other alternative or more hybrid manner could be difficult. The misconceptions hold about what the real conceptual approach could be (e.g. require more time, extensive use of hands-on materials, insufficient emphasis on the teaching of procedures) must be overcome by all educators before they have a mind set for new approaches [2].

Nevertheless, literature revealed that human beings mature at different rates [34] with some of them are lucky enough to know what they want to since young while many other young people are still grappling to find the niche areas or skills that they could master or excel although they may have a natural ability to focus on whatever task is in front of them as many things are not that straight forward for them to master, to know what they could make the right academic choices or to do when growing up. For example, some of the youths may need a few years of real-life experiences before they can begin to understand their own identity, what they plan to do with better conceptual and procedural knowledge/skills. Others may want to travel around to understand life better without adding any pressure of expectations on their academic performances. The study on the implementation of the 5E constructivist STEM-based Modular approach to teach primary science in rural areas revealed significant results despite the constraints faced such as resources and technology support. Hence this study showed that more efforts could be made to reach out to a wider audience in marginalized groups as had been reported in the study by [3] to transform public libraries into digital knowledge dissemination centres in supporting lifelong blended learning programmes for rural youths. Such efforts also prevent dropout in the early years as researched by Zaitun & Mahmoud before [6].

From the lessons learnt through analyzing exemplary cases in this study, we may explore wider opportunities to prepare basic education programmes and foundation courses that could be implemented in 'block/theme-based' forms possibly through blended-mode as well as open and distance education as reported by Gil-Jaurena & Malik [38] to consider also gender equality [39] and Sustainable Development Goals (SDGs)[40]. These types of delivery modes are especially suitable in new normal if possible integrated with micro-credentials accreditation, as internship programme with real-life experience in related settings to ensure that youths are feeling better prepared for their future so that they can dedicate more time and energy to their respective fields of studies to achieve their aspirations.

REFERENCES

[1] SEAMEO (2017). *SEAMEO 7 priority areas + action agenda 2016-2020*. Retrieved: https://www.seameo.org/SEAMEOWeb2/images/stories/Publications/Centers_Pub/SEAMEO_Education_agenda/04%20SEAMEO%207%20Priority%20Areas%20Implementation%20by%20Centres.pdf

[2] Andrew, R. (n.d.). Procedural vs. conceptual knowledge – A hybrid approach to teaching mathematics: Nine keys to the hybrid conceptual-procedural approach. Learn Implement Share. Retrieved January 3, 2021 from https://www.learnimplementshare.com/teaching-math-procedurally-and-conceptually.html

[3] AtoZteacherStuff (2012). *Difference between procedural and conceptual knowledge in mathematics.* https://forums.atozteacherstuff.com/index.php?threads/difference-between-procedural-and-conceptual-knowledge-in-math.155556/#:~:text=Procedural%20involves%20working%20out%20a,great%20example%20is%20with%20fractions

[4] Bybee, Rodger W. (2006). *The high school science curriculum: Reflections on learning and teaching.* Full report prepared for the Office of Science Education National Institute of Health, Colorado Springs: Biological Sciences Curriculum Study "BSCS".

[5] Dahmash, Abdul Wali & Noman, Abdel Kawi & Lafras, Thekra (2014). The effect of using Bybee model to adjust the alternative scientific conceptions for students at eighth grade. *Arab Journal of Scientific and Technical Education.* Vol.54, No.2.

[6] Zaitoun & Ayesh Mahmoud (2007). *Constructivist theory and strategies for teaching science*. Oman: Sunrise Housefor publication and distribution.

[7] UNESCO (2016). *Education 2030: Incheon Declaration and Framework for Action for the implementation of Sustainable Development Goal 4 (ED-2016/WS/28).* http://uis.unesco.org/sites/default/files/documents/education-2030-incheonframework-for-action-implementation-of-sdg4-2016-en_2.pdf

[8] DFAT (n.d.). *Basic education: Practitioner level*. Australian Government Department of Foreign Affairs and Trade (DFAT). 4

[9] Oxford Lexico (2021). *Foundation course*. Retrieved January 3, 2021 from https://www.lexico.com/definition/foundation_course

[10] Conner, L., Ng, K.T., Ahmad, N.J., Ab Bakar, H., Parahakaran, S. & Lay, Y.F. (2013). *Evaluating students' performance for scientific literacy, reading and thinking skills in PISA 2009: Lessons learnt from New Zealand and Malaysia*. Paper presented and compiled in Proceedings (refereed) of the 5th CoSMEd 2013, Penang, Malaysia: SEAMEO RECSAM.

[11] World Bank. (2017). *Brief on education in South Asia, World Bank.* n.d. http://go.worldbank.org/G22NKEQZP0

[12] Creswell, J.W. (2009). *Research design: Qualitative, quantitative and mixed methods approaches.* 3rd ed. Sage Publications, Inc.

[13] Yin, R.K. (2004). *Case study methods (Rev..ed.).* Thousand Oaks, CA: Sage Publications.

[14] Phillips, J.A. (2007). *HMEF 5014: Education research methodology*. UNITEM Sdn. Bhd.

[15] Johnson, R.B. & Onwuegbuzie, A.J. (Summer, 2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, 33(7), 14-26.
[16] Hammond, L. D., Flook, L., Cook-Harvey, C., Barron, B. & Osher, D. (2020.) Implications for educational practice of the science of learning and development. *Applied Developmental Science.* 24(2): 97-140 Retrieved from DOI: 10.1080/10888691.2018.1537791 on 12 January 2021.
[17] Ng, K.T. (2005). *An evaluation of the scientific creativity and problem-solving behaviours of young learners in the development of investigative project work*. Presentation compiled in refereed proceeding for the 1st CoSMEd 2005 Penang, Malaysia: SEAMEO RECSAM. https://scholar.google.com/scholar?cluster=12807739171209930348&hl=en&oi=scholarr
[18] Ng, K.T. & Nyunt, K.A.K. (2010). The development of an on-line learning hub in SEARCH for youth science and mathematics researchers. In Z. Abas and J. Luca (Eds.), *Proceedings of Global Learn Asia Pacific 2010- Global Conference on Learning and Technology* (pp.1158-1167)(LearnTechLib). Penang, Malaysia: Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/p/34320/
[19] Chin, C.K., Hairiah, M., Miyadera, R., Ng, K.T., Ch'ng, Y.S. & Promsing, N. (2019). Promoting education for sustainable development in teacher education integrating blended learning and digital tools: An evaluation with exemplary cases. In Eurasia Journal of Mathematics, Science and Technology Education. 15(1), em.1653.
[20] Junainah, J. (2022). *Development and effectiveness of STEM science inquiry teaching module based on 5E model in enhancing the achievement and attitude towards science of rural school students.* Unpublished doctoral thesis. Sabah, Malaysia: Universiti Malaysia Sabah.
[21] Pang, Y.J., Chuan, T.C., Syed Ahmad, S.S. & Ng, K.T. (2019). Promoting students' interest in STEM education through robotics competition-based learning (R-CBL): Case exemplars and the way forward. *Learning Science and Mathematics*, Issue 14, pp. 107-121.
[22] Talib, C.A., Rafi, I.B.M., Rajan, S.T., Abd. Hakim, N.W, Ali, M. & Ng, K.T. (2019). STEAM teaching strategies in related subject. In *Education, Sustainability & Society (ESS)*. 2(4), 14-18. https://educationsustability.com/paper/4ess2019/4ess2019-14-18.pdf
[23] Ng, K.T., B. Baharum, M. Othman, S. Tahir & Pang, Y.J. (2020). Managing technology-enhanced innovation programs: Framework, exemplars and future directions. *Solid State Technology*. 63(1s). 555-565. http://www.solidstatetechnology.us/index.php/JSST/article/view/741
[24] Ng, K.T., Parahakaran, S., Febro, R., Weisheit, E. & Lee, T.L. (2013). Promoting sustainable living in the borderless world through blended learning platforms. *Open Praxis*. 5(4), 275-288. Nov 26. Publisher: International Council for Open and Distance Education (ICDE). https://www.learntechlib.org/p/130663/
[25] Ng, K.T. (2007). Integration of human values in HVWSE curriculum incorporating teaching strategies/approaches and assessment/evaluation techniques. In P.Pannen, K.T.Ng, J.Ikhsan, D.Mustafa and Herawati (Eds.). *SEAMEO resource package: Human Values-based Water, Sanitation and Hygiene Education (HVWSHE*). SEAMEO SEAMOLEC and UN-HABITAT. https://scholar.google.com/scholar?cluster=6622390137260114690&hl=en&oi=scholarr
[26] Ong, E.T., Ng, K.T., Mohd. H.I., Norwaliza, A.W., Fauziah, M.S., Nurulhuda, A.R., & Charanjit K.S.S. (2021). Investigating the attitudes towards Science among secondary students of orang asli and mainstream ethnicities in Malaysia. *Review of International Geographical Education (RIGEO)*, 11(9), Spring, 2021
[27] Choong, C. (2022). *Sustainability factors for Private Higher Education Institutions in Saudi Arabia.* Unpublished doctoral thesis. Kuala Lumpur, Malaysia: Asia E University.
[28] Ng, K.T., B. Baharum, M. Othman, S. Tahir & Pang, Y.J. (2020). Managing technology-enhanced innovation programs: Framework, exemplars and future directions. *Solid State Technology*. 63(1s). 555-565. http://www.solidstatetechnology.us/index.php/JSST/article/view/741
[29] Ng, K.T. (2012). *Selected student research projects of the 5th Search for SEAMEO Young Scientists (SSYS 2006) Congress.* 20 Penang: SEAMEO RECSAM. https://www.researchgate.net/profile/Khar_Ng/publication/292605229_1BookSSYS_2006-Compile-v100712-Final/data/56af75ca08ae9f0ff7b25b2b/1BookSSYS-2006-Compile-v100712-Final.pdf
[30] Ng, K.T. (2017). Development of transdisciplinary models to manage knowledge, skills and innovation processes integrating technology with reflective practices (Editor's choice). *International Journal of Computer Applications (IJCA)(0975-8887)* Scholarly peer-reviewed research publishing journal No.2, pp. 1-9. Retrieved January 1, 2020 from https://www.ijcaonline.org/proceedings/icrdsthm2017 and https://research.ijcaonline.org/icrdsthm2017/number2/icrdsthm2017022.pdf
[31] Tan, K.A., Leong, C.K. & Ng, K.T. (2009). *Enhancing mathematics processes and thinking skills in values-based water education.* Presentation during 3rd CoSMEd 2009. Penang, Malaysia: SEAMEO RECSAM. https://scholar.google.com/scholar?cluster=15529001711688293075&hl=en&oi=scholarr
[32] Tan, K.A., Ng, K.T., Ch'ng, Y.S., & Teoh, B.T. (2007). *Redefining mathematics classroom incorporating global project/problem-based learning programme.* Presentation during 2nd CoSMEd 2007, 13th to 16th November. Penang, Malaysia: SEAMEO RECSAM. https://scholar.google.com/scholar?cluster=15529001711688293075&hl=en&oi=scholarr
[33] Toh, L. Yeap, C.H., Ng, K.T. & Isma, F. (2007). Cross-curricular teaching incorporating human values: A collaborative research by reflective practitioners. In *Learning Science and Mathematics (LSM) online journal.* 11(2), pp.9-31.

https://scholar.google.com/scholar?cluster=7248508657243676708&hl=en&oi=scholarr

[34] SEAMEO (2017). *SEAMEO 7 priority areas + action agenda 2016-2020*. Retrieved: https://www.seameo.org/SEAMEOWeb2/images/stories/Publications/Centers_Pub/SEAMEO_Education_agenda/04%20SEAMEO%207%20Priority%20Areas%20Implementation%20by%20Centres.pdf

[35] Tan, K.A., Leong, C.K. & Ng, K.T. (2009). *Enhancing mathematics processes and thinking skills in values-based water education.* [36] Presentation during 3rd CoSMEd 2009. Penang, Malaysia: SEAMEO RECSAM. https://scholar.google.com/scholar?cluster=15529001711688293075&hl=en&oi=scholarr

[36] Tan, K.A., Ng, K.T., Ch'ng, Y.S., & Teoh, B.T. (2007). *Redefining mathematics classroom incorporating global project/problem-based learning programme.* Presentation during 2nd CoSMEd 2007, 13th to 16th November. Penang, Malaysia: SEAMEO RECSAM. https://scholar.google.com/scholar?cluster=15529001711688293075&hl=en&oi=scholarr

[37] Toh, L. Yeap, C.H., Ng, K.T. & Isma, F. (2007). Cross-curricular teaching incorporating human values: A collaborative research by reflective practitioners. In *Learning Science and Mathematics (LSM) online journal*. 11(2), pp.9-31. https://scholar.google.com/scholar?cluster=7248508657243676708&hl=en&oi=scholarr

[39] UNICEF (2017). *Basic education and gender equality: Quality of education.* UNICEF, 2010. Retrieved 18 September 2017, https://www.unicef.org/education/index_quality.html [3] Alizah, A., Lee, T.L., Ng, K.T., I. Noraini & SZSA Bakar (2017). Transforming public libraries into digital knowledge dissemination centre in supporting lifelong blended learning programmes for rural youths. Acta Informatica Malaysia (AIM). https://ideas.repec.org/a/zib/zbnaim …

[40] United Nations (2017). *Sustainable Development Goals (SDGs).Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*. https://unstats.un.org/sdgs/report/2017/goal-04/

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