The Strategies in Adapting Frugality in Science Education during the COVID-19's School Closure

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Abstract

During the Movement Control Order, the formal schooling routine was distrupted. Most of the time, formal schooling involves blended learning in school, remote learning at home, or a combination of both. At the same time, the frequent school closures, as a response to the local number of COVID-19 cases, also limit access to educational resources such as materials and apparatus in science laboratories. Due to a challenging situation, the possible idea of frugality in science education was explored. A teacher conducted action research to investigate the strategy for adapting frugality in science education. The qualitative data was collected through both concurrent and retrospective reflection to find the strategies for adapting to frugality in science education during the crisis with two particpants. From the analysis, four strategies were identified, which are: 1) lessons could be varied by utilising free resources; 2) flexible learning hours; 3) constructing or purchasing inexpensive lab materials and apparatus; and 4) engaging in scientific inquiry and integrated learning. This exploratory study was set with empirical limits as implied in any action research methodology in terms of high contextualisity and low generalizeability. Despite the challenges this methodology poses, this study is a preliminary study as a critical instance built on the inquisitive and resourceful minds to explore more teaching and learning strategies while abiding by the order of restricted movement.

Keywords: Frugal, Educator, Crisis, Innovative, COVID-19, Malaysia, Remote schooling

Introduction

The Malaysian government mandated to temporarily closure of the educational institutions in an attempt to contain the spread of the COVID-19 pandemic. The urge to abide by this Movement Control Order (MCO) is considered as collective responsibility as citizens as a whole. This emergency order results in inconvenience and requires the citizens to be resilient and adaptive in this challenging situation. In terms of science education, the shutting down of formal schooling is an opportunity to explore the innovative way of teaching and learning within the available resources. Thus, this paper will discuss the exploration of frugal approach in science education during the lockdown period. From research-based experience, later, the paper discusses the principles in embracing the concept of frugality in science education as an adaptive measure during the crisis and lockdown.

The candid account of the initial idea of adapting the frugal approach in science education was based on examining the exceptional situation without any interest in generalisability. The findings of this study will help to lay the initial foundation for future research concerning crisis-related schooling and practical ideas for teachers to facilitate teaching and learning during the school closure.

Movement Control Order

The Movement Control Order (MCO) was made under the Prevention and Control of Infectious Diseases Act 1988 and the Police Act 1967 (Mat *et al*., 2020). The prohibition of movement and mass assembly nationwide was started from 18th March 2020 to deal with the rise in COVID-19 cases. Under containment phase protocols, the confirmed cases were isolated in hospitals, and their contacts were traced, quarantined in hotels, hospitals, and holiday camps.

The drastic government actions are to curb the spread of the virus that could potentially become dire (Viner, 2020). The unusual obligation to the order disrupted traditional formal schooling systems, leading to the shift to homeschooling (Bol, 2020) or refered as remote learning or distance learning. The shift, however must comply with the 'Standard Operating Procedure (SOP) of Prevention of Infectious Disease Coronavirus 2019 (COVID-19) at schools nationwide (KPM, 2020a). Thus, government and private premises, including nurseries, government, and private schools, including boarding schools, international schools, *tahfiz* centres as well as primary, secondary and pre-university education institutions, are shuttered off for a while or run remotely.

Nevertheless, as expressed by UNESCO (2020), parents are unprepared for the sudden transformation caused by this pandemic. For example, the reliance on the structured curriculum education professionals (Hardman & Norhaslynda A-Rahman, 2014), national schooling system (Sumintono, 2015), logistic challenges (Mohamad & Ali, 2017), sceptics in home-based education and uniformed impromptu decision has made the shift from traditional school to distance education difficult. The term 'homeschooling' during the crisis might get confused with the traditional homeschooling movement, which is not related to COVID-19. As compared to the current situations, usually, the homeschooling is not governed or funded by state bodies (Aurini & Davies, 2005). To define, 'homeschooling' refers to 'parents or guardians educating their children at home by choice,' (Luffman, 1997, p. 30) as distinct from educating a child at home because he/she is not able to attend school. However, current COVID-19 related-homeschooling is an impromptu decision and crisis-responding. In this article, the teaching and learning activity which is shifted from school to home during the crisis is referred as remote-schooling (Mohamad Nasri, Husnin, Mahmud & Halim, 2020)

Obviously, the adaptation to the limited physical materials and facilities due to school closure during the crisis is an opportunity to learn to 'survive schooling during this tough time'. According to Gray (2016), schooling is a medium to teach a designated curriculum of preselected skills, concepts and beliefs using deliberate procedure. Thus, being optimistic, this research promotes the reaction towards COVID-19 pandemic as a precursors for much versatile and flexible schooling system in Malaysia. The most prominent action taken by the government is to enhance the

communication technology and build virtual bridges among teacher-student to allow distance learning for free or susidized. Among the mediums of telecommunication technologies during the crisis are television, live broadcast, social media, mobile application, and internet-mediated software (KPM, 2020a, 2020b). These platforms provide the quality of free online worksheets, and paired with teacher proactive effort to reach the children by various means including 'bring home learning packages' at the areas of limited internet coverage. Likewise, in science education, the lesson is not just about the textbook worthy-notes delivered by school personals. The science lesson may be extended to the resources and material from globally accredited institution that provide virtual tour to nature (Martínez-Graña *et a*l., 2013), gamification (Pirker & Gütl, 2015; Lim, Nonis, & Hedberg, 2006), live-chat with scientists (i.e., NASA scientist at https://science.nasa.gov/live-chat), and content-specific online courses (i.e., https://www.edx.org/ or www.khanacademy.org/).

In short, despite the challenges of adapting to the new norm of 'schooling', the pandemics enhanced teacher–community relations, leading to cooperation and solidarity around education in the home setting. This article suggests that the large multitude of available options and government support for distance learning could be a paradigm shift for the standard-schooling ecosystem. It could therefore be argued that, given the various means of learning and alternative instructional pedagogy; possibly allow the cultivation of the scientific mind amongst school-aged children to be creative and innovative yet resilient. In fulfilling all these aspirations, it is suggested that adaptive measures in crisis-schooling should be acknowledged as challenges during the confinement period. In the same time, the challenge of scarce resources and limited access to the school facility during the school closure could be viewed as an opportunity to implement the frugal approach to education at home with the proper guidance from the teachers, parents, or tutors.

Frugality

Frugal refers to economic or thrifty. In terms of economic, frugality implies budgeting expenditures and prudent planning in the disposition of resources to avoid unnecessary waste or expense. To some extent, thrifty refers to a careful and saving use of resources through proper management. In the geographical "area with scarce resources," most aspects of life were innovated without a heavy reliance on "modern gadgets."The broad array of technical inventions to assist in agriculture and farming changed the relationship of human-material in some rural areas of India, China, and Africa (Paskins, 2020). The idea of frugal innovation has also started to welcome mass-scale production as a frugality that could bring the innovations emerging specifically from the grassroots level (Wierenga, 2015). The researcher in Manu Prakash Lab at Stanford University, for instances, worked on various frugal innovation idea to promotes open ended scientific curiosity and inquiries in communities. They comprehensively developed novel products with low cost, ready-available materials, such as the ultra-affordable origami-microscope (Cybulski, Clements, & Prakash, 2014) and the hand-powered paper centrifuge (Bhamla, Benson, Chai, Katsikis, Johri, & Prakash, 2017).

Besides the innovative idea from the 'area with scarce resources', some researcher also studied the traces and adaptation of frugality back throughout the historical timeline. Warret (2019) studies the traces of diverse ways of putting material possessions into the service of the experiment. This thriving domestic culture of inquiry

was eclipsed by new forms of innovative culture in the nineteenth century, however, culminating in the resource-hungry science of the twentieth. As compared to the term 'frugal', Warret (2019) focuses on how great inventions were developed without any modern equipment like nowadays, and he called it ‘thrifty science’. For instance, Miticool the clay-refrigerator invented by a villager in India (Radjou, 2016) is conceptually similar to the Zeer pot used by ancient Arabs. The pot was later commercialised in Africa and patented (Abba, 2000). At a much more formal level, since the 2000s, the term ‘sustainability" has started to be the central idea in research agendas related to the environment in pure science, applied science, and the humanities. As scientists grapple with the need to make their research more environmentally sustainable, the practise of frugal science may have started to become the mainstream of scientific endeavour.

In Malaysia, the call towards sustainable living started to gain popularity through ‘frugal’ or ‘thrifty’ approaches as well. The initiatives towards maintaining and repairing the existing products have already prompted the ‘makerspace’ and ‘hackerspace’ even before the COVID-19’s lockdowns. In fact, the concept of environmental sustainability began with the ‘environment-conscious’ movement after Rachel Carson’s seminal work was published in 1962 (Lytle, 2007). In the 1980s, the term "sustainability"became popular when the International Union for the Conservation of Nature published the World Conservation Strategy, including an entire section called "Towards Sustainable Development" (Mitcham, 1995). Since then, the campaign to modify human behaviour has started to upscale to the global level, including in Malaysia. Recently, the concept of "sustainability" is always regarded as one of the central ideas in policymaking and research agendas infused and embedded in science curricula.

Science teaching and learning

The science curriculum in Malaysia is made up of four components. First is the body of scientific knowledge. The body of knowledge includes theories and concepts arranged according to cognitive maturity. The second component is scientific skills. Scientific skill training predominantly focuses on technical skills and functional aspects of performing laboratory experimentation (Fadzil & Saat, 2017). The third component is scientific thinking through various modes of learning activities (Abd Rauf, et al., 2013). Finally, the noble value. In the Malaysian National Curriculum, noble value is the affective domain, which focuses on the development of feelings, emotions, and attitudes for the wholesome development of an individual (John, 2018). From the four components of science curriculum, undoubtedly, the body of knowledge is fast becoming available and easily disseminated to school-children via digital and non-digital platforms during the crisis. However, the pause in standard schooling possibly impacted the other three components.

To bridge the gap of the remaining component, the children should be engaged with activities, possibly induced into a more creative and innovative way of learning at home. In fulfilling all these aspirations, promoting the frugal approach in science education is a practical solution to be incorporated into future crisis-schooling plans. In terms of science education, a frugal approach may allow formal science learning to continue despite the obligation to have and sustain available resources (Froschauer, 2010; Radjou & Euchner 2016).This action research explores digital and non-digital resources, flexible learning hour, frugal lab ware, and thrifty approaches in science education during the Movement Control Order (MCO) in Malaysia.

Methodology

This study employed Action Research (AR) methodology (Stapleton 2021; Kindon and Elwood 2009). This research was based on the teacher's continuous reflection and refinement on their own practices to meet the needs of the lesson goal.Qualitative analysis was used to arrive at an understanding of the overall data to be presented as a finding of this study. As a result, the data was carefully reviewed over time to ascertain the study's findings. This AR was divided into four stages: planning, action, reflection, and evaluation.

Planning

The aim of this short study is to build initial understandings of the frugal approach in science education during the resource-scarce situation of COVID-19. The data was gathered from 18th March 2020 until 14th August 2020, with two primary-aged children in a home setting. The qualitative analysis attempted to discover the fundamental strategies for adapting to frugality in science education by a certified government school teacher using the national curriculum during the lockdown. The teacher deployed an eclectic approach to science teaching and learning (Salleh et al., 2014).

Action

This study takes advantage of the more than 10 years of craft knowledge of the certified teacher. The teachers were given autonomy to plan and conduct the intended lesson. Teachers articulate their thoughts on their own practises and modify them according to the context to meet the challenges of MCO.

Reflection and Evaluation

The data is collected continuously according to the teacher’s reflections. The discourse on the collected data provides insight on the modification and adaptation of teaching and learning according to the general principle of frugality and the eclectic teaching approach.

Three primary data sources were analysed according to the four step-guidelines by Vaismoradi, Jones, Turunen, and Snelgrove (2016), namely initialization, construction, rectification, and finalisation until the emerging themes were identified. As the study is an action research, the credibility and generalizability of the data to be extrapolated to a larger population was limited. The consequences of the selected action were somehow unique or incomparable to others.

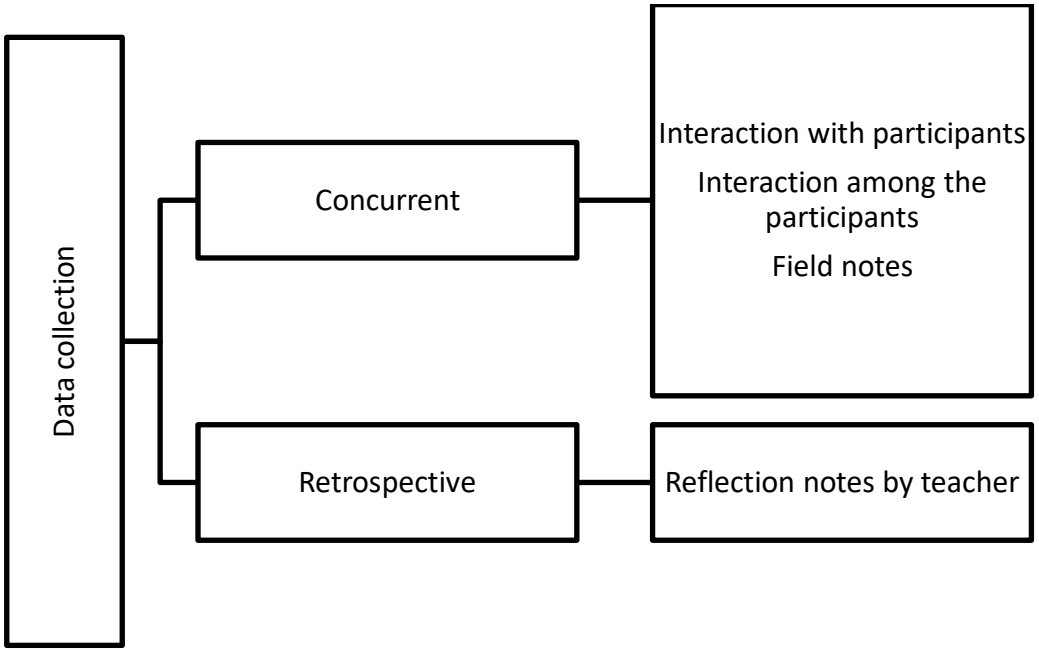

Figure 1: The summary of procedure of data collection

Results and Discussion

From the study experience, the adaptation of frugality considers substantial cost reduction and concentrates on fundamental functions in knowledge transfer and optimised learning ordeal. All these three considerations focus on the lesson resources: pedagogy and technique; laboratory setting and apparatus. From the study experience, several strategies were identified as useful guides to adapting frugality in science education at home.

Lesson could be Varied Employing Free or Affordable Resources

Both participants of the study were allowed to learn virtually with the teacher guidance. Besides the traditional printed resources, the teacher uses a mobile e-learning platform and allows the participants to explore the digital learning platform. In this semi-structured lesson, the participants also allowed to pick and choose the topic they would like to learn about from the syllabus with teacher agreement. Then, the science lesson was planned and tailored accordingly by the teacher. From the observation, most of the time, the participants chose to follow the national syllabus. Only sometimes, they flipped the syllabus to get to know what was available.

The idea was that the science lesson could be stretched out from the textbook towards endless information virtually. Since the Malaysian National Syllabus is scaffolding in nature, the syllabus and curriculum could be the basis of a benchmark to choose the useful links according to a participant's cognitive maturity. The exam-standard, age-appropriate materials for teaching, and learning can be easily downloaded for free or with some subscription fees.

Besides, teacher also tried to use some free online introductory college-level courses as well. However, the introductory course contents are inappropriate for the participant's cognitive level. The other reliable option is a free online learning resource

that is arranged similarly to a school syllabus, such as Khan Academy. This learning platform provides more systematic learning experiences as the teacher can track the progress at the individual level. As the teacher tries to promote self-paced learning without teacher assistance, the learning only persists for a short period of time. In this study, the participant's attention span is approximately seven minutes in one-way learning without teacher assistance. From the study experience, the participants easily disengaged when in a passive learning environment.

For much more specific content, the teacher could also look into which government bodies, research institutes, and non-governmental organisations are the advocates in a particular area of conservation, hosting live-lectures and streaming. For instance, the researcher at Marecet Marine Mammal Research, Langkawi, hosted the Watch Party via Facebook every Wednesday since the lockdown. The participants commented that the experience was like "aspiring but don't really understand the discussion" as they could leave comments and get feedback immediately with the field expert. Thus, conversation with the field experts is inclined to serve as motivation rather than a means of learning the content knowledge.

The lockdown limits the children's field trips and nature walks. The virtual tour is seen as a learning opportunity to allow the children to experience the "outdoor" lesson. For example, the participant gets a chance to tour the Houston Zoo (https://www.houstonzoo.org). The digital tour allows some "wow" factor in the lesson, but it does not keep the participant engaged in the activities. In the bigger picture, all these resources are useful to enrich participants' experiences in learning within the four-walls of a home during a pandemic. However, the efficiency of the virtual-tour should be further studied. Another important is, since most of the links are in English, teacher assistance is required for bilingual participants. Google translate and online-thesaurus are also helpful throughout the lesson. The simultaneous use of several digital teaching aids would take a much longer time to surpass a learning area.

Flexible Learning Hour and Focusing on Science Literacy

Science is everywhere and could be learnt at anytime. Learning science during the crisis-schooling should open for more observation and awareness. The participants allowed choosing the preferred learning time and duration as long as the learning objectives are achieved at daily basis. The participants are also allowed to have flexible learning area in house. From overall observation, the participants tended to have their own comfort area. Even though the instruction was conducted in a much formal area, the participants tend to translocate themselves to other places to complete the activity or task given. Since this phenomenon is rarely seen in a national school setting, this young participant loves to move around after 15 to 30 minutes of sitting. These pauses to move seem to ease the participant to keep engaging with the lesson for a more extended period. The flexible learning hour and the location are emphasized to make the learning as a subjective experience rather than formalised learning. As compared to the scheduled-learning at school, the case context is self-chosen learning time to reduce the effect of stressful containment period..

In addition, the frugal approach emphasizes on problem solving activity. The science lessons have been interpreted in daily life to create scientific minds such as reading the ingredients of packed food, the heating effect on food, the innovation of fan, or anything in the home that might spark interest in learning science. The

participants took some times to readjust themselves to 'view science' outside book. This contextual-learning approach would be advantageous in employing readily available resources, however the duration to complete the lesson takes longer time.

Built or Purchase Cheaper Lab Ware

Science experiments are the backbone of a science lesson. Experiments are meant to be practical and straightforward, especially for children below 12 years old. The goal of an experiment in primary school-aged children should be to develop cognitive, psychomotor, and manipulative skills rather than hypothesis testing. During the containment period, the participant conducted the virtual experiment. From the case studied, the participants have difficulty comprehending the virtual experiments. Nonetheless, performing experiments without standard lab ware is uncommon. During the financial and resource-scarce moment, the lab-standard apparatus and material are considered expensive.

Homeschooling equipment and materials are available for purchase online. Still, some require a subscription to the specific curriculum. This option is relatively expensive as well. Another option is the labware mimics, which are available at a lower price on an e-business platform. Adaptation frugality during the lockdown allows exploration of the apparatus for the participants at a lower price. The e-business platform links international suppliers alongside local suppliers to offer diverse purchasing experiences. For example, the electrical circuit, microscope, robotic kit, solar panel, plastic-ware apparatus, and telescope could be purchased at a lower price. When compared to a normal purchase, the requested labware took longer to arrive during the crisis. It means the teacher needs to identify and make a purchase a month earlier.

To manifest the frugal approach in decision-making and problem solving, the crisis-schooling during the lockdown is an opportunity to create or innovate the lab ware. Ideally, the participant could be involved in the brainstorming and development of the lab ware. As the result, the preparation of practical session requires extended period. To illustrate is the pH test using the blue pea (Clitoria *ternatea*) extract and hibiscus (Hibiscus *rosasinensis*) extract. Both flowers are available in the tropics, and they can change their hue according to the pH. Besides ‘backyard’ material, the measuring cylinder could be substituted with a kitchen standard measuring cup, and any recycled Mason jar could serve as a beaker. The basic principles of the material and apparatus should be understood before the substitutes are chosen. In the mentioned example, the natural colour of the blueish blue pea hue changes per pH, which is similar to litmus paper. As such, the properties of the beaker, which could withstand high temperatures and be transparent for observation, were similar to those of Mason's jar. Experimenting by using simple and cheaper materials allows the participant to get involved actively without anxious of breaking the 'recycled' or cheaper apparatus. The consequences of using non-standard lab ware built room for exploration and cultivated more interactive lessons.

Scientific Inquiry and Integrated Learning

The basic ideas of the development of science and technology are according to decision- making and problem solving. Science learning should be the venue for observation, reporting, and induce inquiry. Allowing the home-based science education by adapting frugality may serve for better exploration in science lesson. During the crisis-schooling, there is an opportunity to integrate the science lesson into

another discipline. For example, the integrated lesson could be conducted by understanding the importance of COVID-19 pandemic, statistics, geography, and even the religious-diversity on dealing with this issue.

In this study, the affordable learning resources for science education also retrieved from the contextual learning. The practice of science when baking, repairing home appliances, environmental care, and self-care by having a healthy lifestyle. For instance, the participants were taught to lodge a scientific-report after using the hand-sanitizer. The report emphasized on the critical observation using all five senses before and after using the product. At another occasion, the participants were encouraged to collect the vegetable scrap to be used as fertiliser.

The well-documented, tested yet free curriculum outline is an important guideline to approach the students individually (Eberly, Newton, & Wiggins, 2001). The scaffolding nature of Malaysia syllabus designed to explore the science' lesson layer by layer' according to the standard individual cognitive maturity. Within the framework of science education, the choice of the lesson, learning material, and seating area at home are conducted in much flexible manner compared to school (Haghighi, Mohammad Moslemi, & and Mahmud Mohd Jusan, 2012). The non-exam assesment also adopted to give the right for the participants to manage their own remote-schooling experience. To reduce the crisis-related effect, the participants also exempted from any performance test within the study period.

This study also found out that, by adapting frugality, science education could be led towards the less-structured lesson (Hamer, 2000) compared to mainstream school (Valikhani, 2015). The participants tend to move around, take a short break during the lesson, and search for extended information. In term of much economical option of learning resources, most of the learning materials accessed from the internet besides the printed books. In normal case, access to the digital equipment considered as expensive. However, this study context suggested a different view. The Malaysian government support during the crisis could view the digital content as frugal resources as well. As compared to the normal situation, the mobility restriction order limits the access to the library or thrifty bookstore, which may be the option to search for cheaper material. In the Malaysian context, the government allocated reimbursement in digital learning and communication initiatives during the crisis (MKN, 2020) and encouraged Industrial Revolution 4.0 (Mohamad, *et al*., 2018) lately accompanied by extensive access to the internet- especially in city area. Moreover, the finding also fits most of the trends in Education 4.0 as per listed by Anealka (2018).

The finding indicated that the learning experience during the school closure could be enriched by turning the adversity to an opportunity. Frugal in science education could serve as a venture to nurture scientific mind to accept sustainability as a responsible lifestyle (Albert, 2019) and being resiliently innovative (Timothy, 2017). However, the preparation of lesson material and brainstorming yield a longer duration of learning compared to traditional schooling. Although the lagged-time per topic is acceptable in non-exam grade, this issue should be weighted if this idea is meant to be adapted to exam-preparatory grade.

Conclusion

From the finding, four strategies of adapting frugality in science education during the time of crisis were identified, which are: 1) lessons could be varied by utilising free

resources; 2) flexible learning hours; 3) constructing or purchasing inexpensive lab materials and apparatus; and 4) engaging in scientific inquiry and integrated learning.

The research was conducted during the COVID-19 lockdown by a certified science teacher. This is an important aspect to be considered. The familiarity and understanding of the syllabus are vital to guide in adopting and adapting the lesson throughout the process. The basic understanding of curriculum, syllabus, cognitive maturity, pedagogy, and content knowledge of the teacher will allow the fluidity in the learning process much guided. Therefore, the idea of adapting frugality requires basic eacher training if the one's aimed to explores the frugal approach in science education.

The crisis-responding science education is an opportunity to cultivate the problem solving and decision making. As compared to school, this action research involved lesser participant. Thus, the participant could be involved in the lesson plan; the topics, the activity, project and experiments. Adapting frugality in science education also means there is room for try and error. The teacher continuously implemented an eclectic approach of teaching using multiple educational resources and stick with the best-fit practices, as an action research implies. The participant's response towards all the innovative ideas should be considered to be maintained before decided to pick a new one.

There is a limitation to this study that it will be perceived as insubstantial due to the length of the study and the small number of participants. Elger (2010) explains that the value of exploratory studies is in identifying key features of a case and its context. For this study, the exploratory study was meant to investigate the practical solution of a science lesson during the lockdown. The data may be insignificant enough for inductive theorising, as some aspects may be covered less intensively. Besides, this action research is highly contextualised and heavily relies on participant reflective practise during the teaching and learning process, so it has limited generalizability. To conclude, this study suggested that the frugality approaches in science education might serve as a practical solution during the crisis within a small group of students.

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