

Knowledge and Practice among Primary School Science Teachers on the Topic of Climate Change

Darsshni Govindarajoo^{1#} & Lilia Halim²

^{1#}, ² Fakulti Pendidikan, Universiti Kebangsaan Malaysia, Bangi, Malaysia

[#]corresponding author <p101346@siswa.ukm.edu.my>

Received first draft 30th May 2022. Received reports from first and second reviewers (15 June 2022 and 6 July 2022). Received revised draft 30 November 2022. **Accepted** to publish 20 December 2022.

Abstract

Purpose and Research Question - In this study, the primary aim is to determine the level of climate change knowledge and practices on primary school Science teachers. This study mainly focused on teachers' knowledge regarding the roots and impact of climate change.

Methodology – The survey design using a questionnaire was employed to determine the level of teachers' knowledge and interviews were conducted to ascertain teachers' practices. Shulman's conception of teacher' knowledge was used in this study. A total of 59 primary school science teachers were involved as respondents in this study.

Findings - Data were analysed using SPSS Windows version 22.0 software. The mean score is 4.16, which shows that the respondents, in general have sound climate change knowledge. Furthermore, the interview data indicated that some teachers misunderstood several scientific facts related to climate change. The interview also showed that the teachers do not teach in depth about climate change or any other sustainable topic. In-service teachers should attend more workshops and courses on climate change.

Significance and Contribution in Line with Philosophy of LSM Journal – This study showed that attending in-service workshops and courses on climate change could help build more understanding on the pedagogy of climate change and increase awareness on the profound impact of teaching climate change at an early age, specifically in primary schools.

Keywords: *Climate change; Climate change causes; and effects; Teachers' knowledge; Teachers' practice*

Introduction

Background and Overview

Environmental problem has become a concern to many scientists for centuries. This can be seen through various studies, reports, campaigns, and conferences conducted like *Agenda 21 of Rio declaration* in 1992, the 2001 *Intergovernmental Panel on Climate Change (IPCC)*, and the Copenhagen conference 2009. These efforts are becoming more significant as the world has started to feel the impact of climate change (Ekpoh & Ekpoh, 2011).

Chang and Pascua (2017) reported that various parties have call for intervention on climate change to start from childhood to curb this global issue. Ekborg and Areskoug (2006) in Seroussi et al. (2019), argued that citizens need to be provided with information on climate change so that society can act appropriately. Seroussi et al. (2019) also mentioned that the media's involvement and teachers' education on climate change in schools are essential in cultivating young people's beliefs

and knowledge. Environmental awareness should be fostered from young age. This can help prepare the younger generation to face and address the effects of climate change. Thus, early education on climate change, specifically in secondary school is viewed as essential to combatting climate change (Karami et al., 2017).

Sharma (2012) highlighted the role of education as a social solution in comprehending how the state of our environment is linked to modern development. Subsequently, it can help form sustainable and accountable behaviours among citizens. In this light, Serroussi et al. (2019) discussed the important roles played by teachers in building awareness and knowledge of climate change. Teachers who are knowledgeable about climate change factors can influence their students to take on a proactive approach towards environmental conservation (Stevenson et al., 2016). Studies on different fields have shown that a big proportion of students are not receiving adequate and correct climate change education, and many teachers lack knowledge on the pedagogy and content related to this topic (Hung, 2014).

In the research, Serroussi et al. (2019) also revealed many secondary and primary school teachers lack knowledge on climate change, especially the in-service teachers compared to the trainee teachers. According to studies, teachers' greater level of knowledge on the variables that produce climate change helps them impact their students about climate change (Stevenson et al., 2016). Many teachers are confused about how or what to teach about climate change, and many students are not receiving enough and accurate instruction, according to research done in a variety of circumstances (Hung, 2014). Turner et al. (2009) further described environmental literacy among students will be increased with more concern towards the state of the environment, a positive attitude toward environmental conservation and higher environmental awareness.

The lack of environmental knowledge among primary school teachers was highlighted in Esa (2010). This has resulted in fewer implementation of environmental activities in schools (Esa, 2010). Past studies mostly focused on the link between misconceptions of climate change, the link between teachers' teaching practices and environmental action, and conceptualising climate change through classroom activities (Wise, 2010). In addition to the level of teachers' knowledge, studies have been examining students' awareness of climate change. However, there are limited studies on teachers' awareness. (Liu et al., 2015).

There are many studies involving students in other countries, but studies on teachers' awareness on climate change (Esa, 2010), especially in the Malaysian context is still lacking. In addition, Haliza (2018) states that public awareness in terms of education is given less attention in Malaysia. Furthermore, the Malaysian National Climate Change Policy established in 2009 has acted in several sectors through the adaptation and mitigation measures in several sectors such as industry, tourism, transportation, and infrastructure but not in education. Additionally, based on the Malaysia Sustainable Development Goal 2019 report, the implementation of climate change issues through education is unavailable yet. Folaranmi et al. (2017) argue that all teachers need to be knowledgeable about a variety of natural events in order to prevent misunderstandings among students. Teachers can have a positive impact on how well students grasp environmental issues like global warming. As a result, teachers need to be knowledgeable about the topic in order to increase students' awareness of climate change.

When teachers use effective form, possess strong pedagogical knowledge, and have a positive perspective on the surroundings, students learn information successfully (Esa, 2010). Shulman (1987) argued on the importance of good pedagogical content knowledge (PCK) among teachers so that they can foster students' understanding when teaching science. In order to influence students to achieve the optimal learning outcomes, teachers need to have a high PCK, according to a study by Keller et al. (2016). Nevertheless, numerous research indicate that low PCK is common among

new teachers. For instance, according to Richardson et al. (2017), science courses were specifically designed for trainee teachers to enhance their PCK in science teaching.

Rationale and Objectives of study

The above discussion showed evidence of a research gaps on teachers' knowledge on climate change. Hence, there is a need to ascertain the extend of primary school science teachers' knowledge on climate change and to examine teachers' pedagogical practices in teaching climate change. As a result, this research can provide knowledge and create awareness on the importance of climate change in the context of education. This study will determine the level of primary school science teachers' knowledge on climate change in teaching science. This study also focuses on teachers' practices during teaching and learning to raise awareness of climate change among students.

Theoretical framework

This study's theoretical framework is based on the seven Core Knowledge of Teachers by Shulman (1987). Pedagogical knowledge is a term that refers to the knowledge of teaching methods that occurs in various areas of teaching (Mulholland, 2014). Shulman (1987) identified different domains of teacher' knowledge. These domains are knowledge of educational purposes, aims, and values, general pedagogical knowledge, pedagogical content knowledge, content knowledge, curriculum knowledge, knowledge of learners and knowledge of educational environments

Some researchers have discussed teachers' practices based on Shulman's types of knowledge while other works have combined practical categories to generate a more comprehensive understanding of teachers' practices. This study examined three forms of knowledge, content knowledge, general pedagogical knowledge, and curriculum knowledge.

For students and teachers, Gemmink et al. (2020) believes that pedagogical practice is critical. First, it explains the link between teacher, student, and subject, in which the quality of teacher-student interaction determines teaching and learning quality. Hamre et al. (2014) mentioned the quality of pedagogical practice is critical, particularly in primary education, when psychological demands are particularly crucial for young children's development. Furthermore, as shown in Collie et al. (2016), there is a link between teachers' well-being and teacher-student interactions. The desire to teach and work with children is at the heart of teacher motivation. As a result, research reveal that teachers' pedagogical practise has a significant impact on the quality of their instruction. Kinghorn (2014) investigates when and how teachers confront gaps in their science content understanding during classroom practices. Six secondary school science teachers from three states were observed and recorded while teaching and facilitating in order to document gaps in their science content understanding. the research concludes teachers' practises with regard to student input in the classroom can certainly have an impact on whether and how teachers recognise gaps in their own science content knowledge.

Methodology

Research Design

This is a descriptive survey study. According to Creswell (2005), the survey research design entails a researcher to survey a sample or the entire population. It can be used in both quantitative and qualitative research. Two data collection techniques, namely questionnaires and interviews were employed to determine teachers' knowledge of climate change and their teaching and learning practices in Seremban, Negeri Sembilan. According to Elangkumaran (2009), a set of questionnaires specific and scientific traits to represent a number of the populations through a small

and logical sampling. The study was conducted in the district of Seremban so that the researcher can control data collection method. The choice of location is also based on which district in Negeri Sembilan has the highest number of national primary schools. This study was limited to the Seremban district due to the Covid-19 pandemic as the researchers emphasize safety. Samples from each school was taken randomly. Besides, the locality is also taken into account for ease of access to facilitate the researcher to obtain data.

Population, Sampling and Pilot Study

The study's population is national primary school science teachers around Seremban District, Negeri Sembilan. In the district of Seremban, Negeri Sembilan, there are 110 national elementary schools. To obtain permission to conduct research, the researcher sent the head of the schools an official letter which included a link to a Google Form to answer the questionnaire. Based on the sample size determination table by Krejcie and Morgan (1970), if the population is 70 people, then the sample size required in this study is 59 people.

A pilot study was conducted involving 33 primary school teachers who taught science subjects and had the same criteria as the actual study sample. The selection of 30 to 50 people as the study sample to conduct a pilot study is a good suggestion (Connelly, 2008). The researcher distributed the questionnaire virtually via *Telegram* app to all primary schools in the district of Seremban (SK, SKJC, and SJKT). The pilot study was conducted for a week in selected schools in the Seremban district before the actual study.

Instrumentation

This questionnaire was divided into three sections. The items in Section A probe about the respondents' demographics. Items in Section B focus on teachers' knowledge on climate change factors and items in Section C comprise self-assessment items to examine teachers' understanding on the impact of climate change.

The questionnaire is a modified version of Seroussi et al. (2019). The original version of the questionnaire was adapted from the Yale Project on Climate Change Communication's Six Americas' Survey on global warming, which has been used previous studies involving teachers. For the part B and C questionnaire instruments, the researchers used Cronbach's Alpha to assess the reliability of the items and 0.6 was the acceptable minimum value. If the Cronbach's Alpha value exceeds 0.60 then, the instrument reliability was high and suitable for use in the actual study (Hair et al., 2011). Table 1 shows the reliability index classification for the instruments proposed by (Bond & Fox, 2007).

Table 1 Reliability Index Classification

Indicator	Cronbach's Alpha Value
Very good and effective	0.90 – 1.0
Good and acceptable	0.70 – 0.80
Acceptable	0.60 – 0.70
The item needs to be fixed	<0.60
The item needs to be dropped	<0.5

Table 2 Cronbach's Alpha Value for the Reliability Test of Teachers' Knowledge Level of Climate Change

Questionnaire	Number of Items	Cronbach's Alpha Value
B: Causes of Climate Change	11	0.937
C: Effects of Climate Change	12	0.943

The Cronbach's Alpha value for the teachers' knowledge on the climate change questionnaire exceeded 0.90 (see Table 2), therefore all the items were accepted.

The data obtained through this study is composed of quantitative data. The information obtained from the questionnaire were analysed using Statistical Package for the Social Science (SPSS) version 22.0. Furthermore, the interview data were analysed based on the themes, the causes of climate change, the effects of climate change, teachers' practices.

Findings

Table 3 displays the descriptive statistics to identify the level of primary school science teachers' knowledge on climate change.

Table 3 Mean and Standard Deviation of Science Teachers' Knowledge on Climate Change

	Mean	SD	Level
knowledge about causes of global climate change	4.04	.573	High
knowledge about impacts of global climate change	4.28	.468	High
Total (Teachers' knowledge of climate change)	4.16	.432	High

(Level: Very Low = 1.00 – 1.89, Low = 1.90 – 2.69, Moderate = 2.70 – 3.49, High = 3.50 – 4.29, Very High = 4.30 - 5.00)

This study evaluated teachers' knowledge of two aspects of climate change: their understanding of the factors that contribute to global climate change and their understanding of its implications.

Table 3 presents teachers' knowledge of the causes of global climate change (mean = 4.04, SD = 0.573) and their understanding of the effects of global climate change (both scores. (mean = 4.28, SD = 0.468) are high. Overall, it shows that the score of teachers' knowledge level on climate change (mean = 4.16, SD = 0.432) among national primary school science teachers in Negeri Sembilan is at a high level.

To support the quantitative data obtained, interviews were conducted to further strengthen this study. This section reports the results of interviews with four primary school teachers. A hybrid strategy combining inductive and a priori coding techniques was used to thematically code and analyse the interview data. The researcher chooses the code in advance, in this case depending on the framework and the study questions, and then the analysis starts. This is known as a priori coding. After that, inductive coding is employed. New themes or codes can emerge from the data using this analytical approach, allowing for more concentrated coding of the data.

Coding templates or coding schemes are used to help compose related or similar texts for interpretation (Nicholls, 2016). The a priori coding scheme used in this project has been developed by a priori coding with the help of literature and research questions. Two separate coding schemes were developed under the level of teachers' knowledge of climate change, specifically the causes of

climate change and the effects of climate change. Three separate codes were developed for teachers' practices in teaching climate change. The three coding are pedagogical knowledge, curriculum knowledge and content knowledge. Additional codes that have been identified based on interview results are home practices and values.

The following section reports interview results with four primary school teachers. The teachers were selected randomly based on availability and willingness to be interviewed. Responses to the interview were labelled as follows:

The initial name, teaching experience, level 1 or 2.

Knowledge Level of Primary School Teachers

Determining teachers' awareness on climate change causes and effects is essential in assessing their understanding of it. Each interview started by asking the respondents on their perspective and belief of climate change to learn about their knowledge and understanding of the issue. The respondents were free to interpret and respond to the questions as they were not given any context for the questions. In this regard, most respondents touched on climate change causes including global warming, ozone layer depletion, and deforestation.

'Climate change is caused by deforestation, landscape development, greenhouse effects, increasing carbon dioxide, and ozone depletion' [G, 12, 1].

'Climate change is causing an increase in the earth's temperature, rising sea levels, and the depletion of the ozone layer. Uncontrolled deforestation for the construction of a growing number of housing projects. This has caused the earth's temperature to go up' [T, 24, 2].

Some teachers stated they are aware of the link between climate change and human activities, for example, air conditioners usage and tinted mirrors on tall buildings.

'My teacher once talked about the habit of using air conditioners and the use of tinted mirrors to increase the earth's temperature.' [R, 12, 1].

According to one of teachers, climate change is a change in weather or climate, and caused by the earth orbiting around the sun.

'Climate change means changes in climate from very hot weather to winter or vice versa... It is a natural occurrence that is caused by the circulation of the earth' [Y, 16, 2]

These findings show the teachers' differing perspectives on the causes of climate change. Teachers frequently highlight carbon dioxide emissions and a small number of manmade climate variables, as well as rising temperatures, while explaining climate change. However, the majority of responders point to human-caused climate change as the primary cause.

'Yes, there are indeed natural disasters that contribute to climate change, but I believe humans play a greater role in climate change on earth. And because of human attitudes, climate change is more pronounced' [T, 24, 2].

'Yes, that's what I'm trying to convey. Climate change is indeed the result of human activities that do not think about the impact on our world' [G, 12, 1].

'It can be said so. There is too much human activity nowadays' [R, 12, 1].

Most teachers do not have time to read scientific journals. They rely on mass media such as online reading and viewing or listening to news articles relating to climate change since they have limited time and capacity to absorb and process complex scientific knowledge. A teacher, for example, indicated that she learned about climate change from movies and books. Meanwhile, two more teachers read books and articles to know more about causes of climate change.

'Others are based on readings and movies which in my opinion are very good for our students. For example, the film 2012 tells how the world's climate is changing due to the melting of ice, changing the world.' [R, 16, 1]

'Hmm... through reading, teaching experience for many years, and so on. But mostly through reading' [T, 24, 2].

'I like to read. I once read about climate change on the internet' [G, 12, 1].

Because all respondents were convinced that human actions were to blame for climate change, they were questioned if animal farming and the food industry played a role in it. Except for one respondent, everyone disagreed that animal farming and the food sector are linked to climate change.

'Their food. Meat releases a lot of carbon dioxide into the air. That indirectly causes the climate change' [G, 12, 1].

'Nothing to do at all' [T, 24, 2].

'I don't think it has anything to do with it. What do animal farming and nutrition have to do with science?' [Y, 16, 2].

'I do not think so. What is the connection between animal farming and climate change' [R, 12, 1].

Although there are studies that state that ozone depletion does not cause climate change, all teachers believe that the extensive use of air conditioning is the main cause of climate change as it contributes to ozone depletion.

'The ozone layer is getting thinner due to the use of air conditioning. When there is a hole in the ozone layer, a lot of heat is trapped and the earth's temperature rises. This will cause climate change' [G,12, 1].

'The reason is the use of air conditioners that release CFC gas. The CFC gas depletes our ozone layer' [T, 24, 2].

'I think climate change or global warming is due to the use of air conditioning too so that the ozone layer is depleted' [Y, 16, 2].

'Hmmm, maybe this is because I remember my teacher said that the earth's ozone layer is getting thinner due to the use of air conditioning. Besides, all shopping malls use a lot of air conditioning, especially in developed countries. So I agree it's also a contributor to climate change' [R, 12, 1].

The interviews with the teachers revealed two additional themes, the students' practice at home and the good values practice. A teacher teaching at primary level 2 who teaches pupils aged 10 to 12 years old thinks that the climate change problem is no longer new for teachers. However, he stressed that climate change needs to be taught by parents at home so that it becomes the practice of the younger generation no matter where they are. He also stated that the current generation needs to be good citizens of the earth.

'It's not about knowledge anymore. But more to practice. Pupils need to practice environmental care at home not at school. Parents are too busy working. They close one eye when children throw rubbish in public places or throw rubbish from cars. They forget that small things like this need to be taken into account. Even if we look at the parents, they have been taught about environmental care since they are in school. Do they practice it when they are adults? No. It is because of the absence of practice that it no longer involves teaching or knowledge' [T, 24, 2].

'The younger generation now is all not taught moral values to take good care of the environment at home. They throw trash all over the place and waste paper. All of this needs to be taught by the parents. In school, almost all subjects touch on environmental care and so on. Yet, where is their awareness of caring for the environment? The current generation is very selfish and has not taught moral values. The values must be practiced at home first so that the impact can be seen' [T, 24, 2].

Additionally, these teachers were also interviewed to examine the consequences of climate change. Two out of the four teachers stated that climate change is affecting our livelihood.

'There are effects in certain sectors such as in the agricultural sector. Farmers had to face a longer dry season. I think it also influences the rain and hot seasons' [G, 12, 1].

'It's there, but not too noticeable. Maybe it affects the change of seasons. Now the rainy season comes earlier. The hot season is longer' [Y, 16, 2].

Whereas, the other two teachers feel that climate change has no significant impact on daily lives.

'Hmm, I guess in terms of the hotter weather, I guess it doesn't affect our lives' [T, 24, 2].

'Not too noticeable and I think it doesn't affect our lives' [R, 12, 1].

The teaching and learning practices of primary school science teachers on climate change

Three themes were identified from the interview data. Hence, the discussion will focus on teachers' content, general pedagogical, and curriculum knowledge.

Teachers' mastery of lesson content is important factors to ensure that the teaching and learning process takes place meaningfully. Teachers need to understand the lesson content in depth and then adapt to the student's environmental situation. Teachers' understanding of the lesson content also

helps students build useful cognitive knowledge, relate the ideas obtained with other ideas, and be able to identify students' misconceptions.

The interviews showed that the teachers have high awareness that the primary school science curriculum does not explicitly cover the concept of climate change. Thus, science teachers need to instil values in their teaching and facilitation. Therefore, when interviewed, the teachers clearly stated that they instilled the values of responsibility towards the environment indirectly in the appropriate topics.

'This topic is not in the primary school science syllabus...Yes, we do teach indirectly because as science teachers we always apply values in every learning objective' [G, 12, 1].

'We do indirectly teach this topic. In the summary, if there is a relevant topic, as teachers, we associate it with values' [T, 24, 2].

Each teacher has a variety of teaching strategies during teaching and learning (T&L). In this interview, teachers were asked how they would teach the climate change topic if it were included in the primary school Science syllabus. Two teachers stated that project-based learning help students understand the importance of learning this topic. Some teachers stated the use of technology would help. This shows the teachers are proficient in their pedagogical knowledge.

'In my opinion, this topic should be taught practically, such as learning through projects. From practical, we focus on theory. This is because climate change is a difficult topic to understand by primary school students. I am one of the teachers who like to do projects with students. So I would ask my student to create an appropriate project to examine the effects of climate change. Besides, there is a lot of info related to climate change on social media like YouTube that is suitable for primary school students' [G, 12, 1].

'I will do Project Based Learning. Since the UPSR was abolished, teachers have had more time for projects. I will make sure my students practice the values that I want to instil in them' [T, 24, 2].

Meanwhile, a teacher thinks that this topic is less suitable because they were too young to understand its purpose. He stressed students can learn about climate change in secondary school.

'Yes, it is better, but I think it is less suitable for level 1 students. After all, we also studied it in secondary school. It may be possible to teach only a little as a subtopic' [R, 12, 1].

Another teacher prefers questioning techniques. He stated that the students showed more understanding if they could answer the questions posed by the teacher.

'I prefer to use questioning techniques. For me, it helps a lot for students to think more without relying entirely on the teacher. Depending on the topic we are going to teach' [R, 12, 1].

Discussions and Conclusion

In terms of knowledge, the survey showed that teachers' demonstrated knowledge on climate change with confidence. However, further analyses of the interviews data found some teachers have misconceptions on climate change, reflecting the importance of scientific understanding among teachers. According to Yates (2014), teachers are a major source of misconceptions among students. For policymakers, to develop primary school teacher professionalism, a valid integrated instrument can be used to reveal teachers' weaknesses in their understanding of science material, so that more efforts can be done to reduce the weaknesses, such as through scientific workshops or discussion.

To advance the expertise of primary school science teachers and highlight how student learning in primary schools affects secondary schooling, professional learning communities (PLCs) can be established between science teachers at the secondary and primary school levels. This aids science teachers in primary schools in their efforts to clarify scientific concepts.

To raise a new generation that has awareness and cares about climate change, the issue should be included as one of the goals of science education. In this light, there is a need to improve teachers' attitudes, perceptions, and awareness of climate change. This is because teachers' attitude and knowledge on the environment can motivate students to learn more about climate change. Teachers, according to Kamis et al. (2017) can be catalyst in changing students' attitudes and behaviours on the environment. The study advocated that teachers should have sufficient training on sustainability and environmental education to optimise learning.

Teachers need professional development courses, related programs, and training such as Awareness and Knowledge of Climate Change that integrate teaching and learning activities, which create opportunities for in-service teachers to improve their knowledge. The MOE, the State Education Department (JPN), and the Training and Services Division could organize training and workshops to create awareness on the importance of knowledge of climate change and the negative impacts of climate change, and to introduce climate change as a specific topic in the science syllabus.

Since the Third Malaysia Plan (1976–1980), sustainable development has been a part of Malaysia's educational strategy. Despite the fact that environmental issue are mentioned in educational policies and plans (Mokshein, 2019), its definition and application to the specific Malaysian context have not been completed to now (Balakrishnan, 2021). Malaysian teachers do not have the systemic support they need to become sustainable change agents. As previously said, learning activities about sustainability and climate change should be intensified (Kwauk, 2020). In schools, learning activities are directed around finishing the syllabus and teaching in preparation for national assessments, leaving little time for critical discussion of important environmental issues. Furthermore, it usually only entails low-impact efforts such as conserving energy and recycling. As pointed out by Mustam and Daniel (2018), there is less priority in integrating environmental education into the existing curriculum. In contrast to inquiry learning for enrichment, teachers tend to favour academic learning for examination. ESD is one such component that could be viewed as a distraction that is difficult for both teachers and pupils.

Project-based learning needs to be emphasized to the in-service teachers as the UPSR (Ujian Penilaian Sekolah Rendah) has been abolished. Cross-Curriculum Elements (CCE) such as environmental sustainability, which have recently been incorporated to the curriculum and assessment standard document (DSKP) as an additional value, need to be taught more directly and seriously by instructors. Studies on climate change in the field of education have not yet received the attention of many educators or researchers. The relationship between teachers' level of knowledge and teachers' misconceptions of science facts has certain limitations due to the limited

sample and time. Among the suggestions and improvements to get more comprehensive findings, is to expand the study involving primary school science teachers throughout the country. Besides, future researchers are also suggested to study other variables such as awareness and attitude so that a more holistic finding is obtained. The addition of research questions is recommended to obtain more detailed findings.

The study also reveals that it is time for values to be taught directly. This is because the implicit value teaching does not bring any benefits. After all, the students only practice them at school. Pupils neglect the responsibility to take care of the environment when they are adults. Further research should also study the practice of the values among primary and secondary school students.

Acknowledgement

This study is part of a project funded by the Ministry of Higher Education, Malaysia (TRGS/1/2019/UKM/01/3/4)

References

- Balakrishnan, P. (2021). Chapter 16 ESD in Malaysia. *Curriculum and Learning for Climate Action*. Brill. https://doi.org/10.1163/9789004471818_017
- Bond, T. G. & Fox, G. M. (2007). *Applying The Rasch Model: Fundamental Measurement in The Human Sciences*. Lawrence Erlbaum Associates Publishers.
- Chang, C.H. & Pascua, L. (2017). The state of climate change education – reflections from a selection of studies around the world. *International Research in Geographical and Environmental Education*, 26(3), 177-179, DOI: 10.1080/10382046.2017.1331569
- Collie, R. J., Shapka, J. D., Perry, N. E., & Martin, A. J. (2016). Teachers' psychological functioning in the workplace: Exploring the roles of contextual beliefs, need satisfaction, and personal characteristics. *Journal of Educational Psychology*, 108(6), 788–799. <https://doi.org/10.1037/edu0000088>
- Connelly, L.M. (2008) Pilot Studies. *MEDSURG Nursing*, 17, 411-412.
- Creswell, J. W. (2005). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson.
- Ekborg, M., & Areskoug, M. (2006). How student teachers' understanding of the greenhouse effect develops during a teacher education programme. *Nordic Studies in Science Education*, 2(3), 17–29. <https://doi.org/10.5617/nordina.411>
- Ekpoh, U.I. & Ekpoh, I.J. (2011) Assessing the level of climate change awareness among secondary school teachers in Calabar municipality: Implication for management effectiveness. *International Journal of Humanities and Social Science*, 3, 106-110.

- Elangkumaran, D. (2009). *Hubungan antara kepimpinan pengajaran guru besar dengan komitmen kerja dan kepuasan kerja guru sekolah rendah di zon Tanjung Karang*. [Master in Education Project Paper]. Faculty of Education, Universiti Kebangsaan Malaysia.
- Esa, N. (2010). Environmental knowledge, attitude and practices of student teachers. *International Research in Geographical and Environmental Education*, 19, 39–50.
- Folaranmi A., A., Asukwo, E., & B. Eyiwumi, A. (2018). Comparative Analysis of Senior Secondary Schools Science Teachers and Students Knowledge, Attitudes and Practices to Global Warming in Kwara State, Nigeria. *Journal of Education, Society and Behavioural Science*, 27(2), 1-8. <https://doi.org/10.9734/JESBS/2018/21550>
- Gemmink, M. M., Fokkens-Bruinsma, M., Pauw, I., & van Veen, K. (2020). Under pressure? Primary school teachers' perceptions of their pedagogical practices. *European Journal of Teacher Education*, 1–17. doi:10.1080/02619768.2020.1728741
- Hair, J. ., Celsi, M. ., Money, A., Samouel, P. & Page, M. (2011). *Essential of Business Research Methods* (2nd Ed.). Sharpe, Inc.
- Haliza, A. R. (2018). Climate change scenarios in Malaysia: Engaging the public. *Environmental Science* 1(2), 55-77.
- Hamre, B., B. Hatfield, R. Pianta, & F. Jamil (2014). Evidence for General and Domain-Specific Elements of Teacher–Child Interactions: Associations with Preschool Children’s Development. *Child Development* 85 (3): 1257–1274. doi:10.1111/cdev.12184.
- Hung, C.C. (2014). *Climate Change Education: Knowing, Doing and Being*. Routledge.
- Karami, S, Shobeiri, S.M, Jafari,H., & Hendi, G.N. (2017). Assessment of knowledge, attitudes, and practices (KAP) towards climate change education (CCE) among lower secondary teachers in Tehran, Iran. *International Journal of Climate Change Strategies and Management*, Vol. 9 Issue 3, doi: 10.1108/IJCCSM-04-2016-0043
- Kamis, A., Che Rus, R., Rahim, M. B., Nur Yunus, F. A., Zakaria, N., & Mohd Affandi, H. (2017). Exploring green skills: A study on the implementation of green skills among secondary school students. *International Journal of Academic Research in Business and Social Sciences*, 7(12), 327–345. <https://doi.org/10.6007/IJARBS.v7-i12.3615>
- Keller, Melanie & Neumann, Knut & Fischer, Hans. (2016). The impact of physics teachers’ pedagogical content knowledge and motivation on students’ achievement and interest: PHYSICS TEACHERS’ KNOWLEDGE AND MOTIVATION. *Journal of Research in Science Teaching*. 54. 10.1002/tea.21378
- Kinghorn, B. E. (2014). Gaps in science content knowledge encountered during teaching practice: A study of early career middle school science teacher. Child Psychological Association (APA), Fairfax, VA.

- Krejcie, R. V., & Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, 30(3), 607–610. <https://doi.org/10.1177/001316447003000308>
- Kwauk, C. (2020). Roadmaps to quality education in a time of climate change. Brookings. <https://www.brookings.edu/research/roadblocks-to-quality-education-in-a-timeof-climate-change/>
- Liu, S., Roehrig, G.H., Bhattacharya, D., & Varma, K. (2015). In-Service Teachers' Attitudes, Knowledge and Classroom Teaching of Global Climate Change. *Science Educator*, 24, 12-22.
- Mustam, B., & Daniel, E. S. (2018). Informal and formal environmental education infusion: Actions of Malaysian teachers and parents among students in a polluted area. *MOJES: Malaysian Online Journal of Educational Sciences*, 4(1), 9-20. <https://mojes.um.edu.my/article/view/12641>
- Mokshein, S. E. (2019). *Education for Sustainable Development (ESD) in Malaysia: Policy, program and evaluation*. [Proceedings of the 3rd International Conference on Current Issues in Education (ICCIE 2018)]. Atlantis Press. <https://doi.org/10.2991/iccie-18.2019.2>
- Mulholland, J. (2014). Pedagogical Knowledge. *Encyclopedia of Science Education*, 1–2. DOI: 10.1007/978-94-007-6165-0_204-2
- Nicholls, J.A. (2016) *Understanding how Queensland teachers' views on climate change and climate change education shape their reported practices*. PhD thesis, James Cook University. DOI: [10.25903/0sgf-zg05](https://doi.org/10.25903/0sgf-zg05)
- Richardson, G.R., Byrne, L.L & Liang, L.L (2018). Making learning visible: Developing preservice teachers' pedagogical content knowledge and teaching efficacy beliefs in environmental education, *Applied Environmental Education & Communication*, 17:1, 41-56, DOI: 10.1080/1533015X.2017.1348274
- Seroussi, D.-E., Rothschild, N., Kurzbaum, E., Yaffe, Y., & Hemo, T. (2019). Teachers' Knowledge, Beliefs, and Attitudes about Climate Change. *International Education Studies*, 12(8), p33. <https://doi.org/10.5539/ies.v12n8p33>
- Sharma, A. (2012). Global climate change: What has science education got to do with it? *Science & Education*, 21, 33-53.
- Shulman, L. (1987). Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review* 57(1): 1- 22
- Stevenson, K.T, Peterson, M.N, & Bradshaw, A. (2016). How Climate Change Beliefs among U.S. Teachers Do and Do Not Translate to Students. *PLoS ONE* 11(9): e0161462. <https://doi.org/10.1371/journal.pone.0161462>

- Turner, G., Tekkaya, C., Sungur, S., Cakiroglu, J., Ertepinar, H., & Kaplowitz, M. (2009). Assessing pre-service teachers' environmental literacy in Turkey as a mean to develop teacher education programs. *International Journal of Educational Development*, 29, 426–436.
- Wise, S. B. (2010) Climate Change in the Classroom: Patterns, Motivations, and Barriers to Instruction among Colorado Science Teachers. *Journal of Geoscience Education*, 58:5, 297-309, DOI: 10.5408/1.3559695
- Yates, T.B., & Marek, E.A. (2014). Teachers teaching misconceptions: a study of factors contributing to high school biology students' acquisition of biological evolution-related misconceptions. *Evo Edu Outreach* 7, 7. <https://doi.org/10.1186/s12052-014-0007-2>