EFFECTIVENESS OF NUTRITION-BASED SOCIO-SCIENTIFIC ISSUES SCIENCE LESSONS IN FOSTERING 21ST CENTURY SCIENTIFIC LITERACY AMONG LOWER SECONDARY STUDENTS

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UNIVERSITI SAINS MALAYSIA

2022

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by

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Thesis submitted in fulfilment of the requirement for the degree of Doctor of Philosophy

March 2022

ACKNOWLEDGEMENT

First and foremost, praise and thank you, God, for his showers of blessings throughout my research work to complete the research.

I would like to express my deepest and sincere gratitude to my research supervisor, Associate Professor. Dr Mageswary Karpudewan for allowing me to do the research and provide invaluable guidance throughout the study. I would also like to thank her for her empathy and consideration of me. My heartfelt thanks to my mother, Madam Devi Gopal and my sister Subashini Velamuthu, who always be there for me. Thank you to family and friends, especially Surinder and family.

Thank you to all the USM School of Educational Studies lecturers and staffs for their patient assistance and guidance during my days in the institution. Thank you to all the teachers, students, lab assistants who have given their support and commitments to this study.

And last but not least, I am incredibly grateful to the Ministry of Education Malaysia for providing an opportunity for me to study by aiding me with the *Hadiah Latihan Persekutuan Sambilan* scholarship. Without MOE, Dr Mageswary and USM, it's almost impossible for me to think of a PhD. A million thanks from me.

"All our dreams can come true if we dare to pursue them" – Walt Disney

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LIST OF ABBREVIATIONS

5E's	Engagement, Exploration, Explanation, Elaborate And Evaluation Phases
ANCOVA	Analysis of covariance
BIOSNT	Big Ideas of Science Nutrition Test
BPA	Bisphenol-A
CV	Character and Values
CVQ	Character and Values Questionnaire
DNA	Deoxyribonucleic Acid
GMF	Genetically Modified Foods
GSLQ	Global Scientific Literacy Questionnaire
HOM	Habits of Mind
HOMQ	Habits of Mind Questionnaire
KSSM	Kurikulum Standard Sekolah Menengah
MANCOVA	Multivariate Analysis of Covariance
MASD	Metacognition and Self-Direction
MASDQ	Metacognition and Self-Directed Questionnaire
MASTEC	The Malaysian Science and Technology Convention
MMR	Mixed-Method Research
NCKT	Nutrition Content Knowledge Test
NOS	Nature of Science
OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
SD	Standard Deviation
SHE	Science as Human Endeavour
SHEQ	Science as Human Endeavour Questionnaire
SL	Scientific Literacy

SSI	Socio-Scientific Issues
STS	Science - Technology - Society
TIMMS	The Trends in International Mathematics and Science Study

LIST OF APPENDICES

KEBERKESANAN PEMBELAJARAN ISU-ISU SOSIO-SAINTIFIK SAINS BERASASKAN PEMAKANAN DALAM MEMUPUK LITERASI SAINTIFIK ABAD KE-21 DALAM KALANGAN MURID MENENGAH RENDAH

ABSTRAK

Kebimbangan yang timbul mengenai isu sosio-saintifik pemakanan seperti malnutrisi, obesiti, anemia dan lain-lain menimbulkan seruan untuk meningkatkan kadar literasi saintifik di kalangan murid ke arah menjadikan mereka warganegara global yang dapat menyelesaikan masalah pemakanan secara adil dan saksama sambil bergerak menuju komuniti global yang selamat. Kajian ini mengukur keberkesanan pembelajaran sosio-saintifik berasaskan pemakanan dalam meneroka dan meningkatkan dimensi dan konstruk-konstruk literasi saintifik abad ke-21 dari segi (1) pengetahuan kandungan (2) kebiasaan minda (3) karakter dan nilai (4) sains sebagai ikhtiar manusia, dan (5) metakognisi dan regulasi kendiri di kalangan murid. Dua instrumen digunakan untuk mengukur pengetahuan kandungan pelajar iaitu Ujian Pengetahuan Kandungan Pemakanan (NCKT) dan Ujian *Big Ideas of Science Nutrition Test* (BIOSNT). Tinjauan soal selidik dan temu bual yang dilakukan untuk mengukur perubahan pada pemboleh ubah bersandar. Soal selidik mengenai Kebiasaan Minda (HOMQ), Soal selidik mengenai Karakter dan Nilai (CVQ), Soal selidik Sains sebagai Ikhtiar Manusia (SHEQ) dan Soal Selidik mengenai Metakognisi dan Regulasi Kendiri (MSDQ) dibina daripada *Global Scientific Literacy Questionnaire* (GSLQ) dan disesuaikan dengan kandungan topik pemakanan. Temu bual dilakukan untuk mendapatkan maklumat mendalam untuk menyokong hasil analisis kuantitatif. Kajian ini melibatkan penyertaan 120 murid Tingkatan Dua. Sebanyak 10 rancangan pengajaran harian isu-isu sosio-saintifik berasaskan pemakanan dimasukkan ke dalam manual pengajaran. ANCOVA sehala

dilakukan untuk memeriksa perubahan pengetahuan kandungan mengenai pemakanan. MANCOVA sehala dilakukan untuk menilai perubahan pemboleh ubah bersandar bagi dimensi kebiasaan minda, karakter dan nilai, sains sebagai ikhtiar manusia dan metakognisi dan regulasi kendiri dan konstruk-konstruknya. Analisis ANCOVA sehala menunjukkan perbezaan yang signifikan antara kumpulan kawalan dan eksperimen untuk dimensi pengetahuan kandungan pemakanan. Analisis MANCOVA sehala menunjukkan hasil yang signifikan untuk dapatan keseluruhan kebiasaan minda dan dua konstruk (1) komunikasi dan kolaborasi dan (2) pemikiran/pengurusan maklumat yang sistematik. Perubahan yang signifikan diperoleh bagi dapatan keseluruhan karakter dan nilai dan dua konstruk (1) pandangan dunia ekologi/kasih sayang sosial dan moral dan (2) tanggungjawab sosio-saintifik. Secara keseluruhan, sains sebagai ikhtiar manusia dan dua konstruk (1) ciri pengetahuan saintifik dan (2) sains dan masyarakat/semangat menunjukkan hasil yang signifikan. Juga, dapatan yang signifikan diperoleh untuk keseluruhan metakognisi dan regulasi kendiri dan dua konstruk (1) merancang/memantau dan (2) menilai. Respon temu bual mengukuhkan hasil penemuan kuantitatif. Pendekatan pembelajaran SSI berasaskan pemakanan adalah baru di Malaysia, terutamanya untuk murid-murid menengah rendah dan belum dimasukkan ke dalam kurikulum pengajaran. Oleh itu, pendekatan pembelajaran SSI berasaskan pemakanan harus diperkenalkan ke dalam spesifikasi kurikulum menengah rendah untuk meningkatkan literasi sains abad ke-21 di kalangan murid-murid.

EFFECTIVENESS OF NUTRITION-BASED SOCIO-SCIENTIFIC ISSUES SCIENCE LESSONS IN FOSTERING 21ST CENTURY SCIENTIFIC LITERACY AMONG LOWER SECONDARY STUDENTS

ABSTRACT

The emerging concerns about nutrition SSIs like malnutrition, obesity, anaemia, etc give rise to a call to improve scientific literacy among students to be global citizens who can resolve nutrition issues in a fair and just manner while moving towards a safe global community. The study measured the effectiveness of nutrition-based SSI lessons in exploring and enhancing secondary school students' 21st-century scientific literacy dimensions of (1) content knowledge (2) habits of mind (3) character and values (4) science as human endeavour and (5) metacognition and self-direction and its constructs. Two instruments were used to measure students' content knowledge, the Nutrition Content Knowledge Test (NCKT) and the Big Ideas of Science Nutrition Test (BIOSNT. A questionnaire survey and interviews were conducted to measure the change in the dependent variables. Questionnaire on Habits of Mind (HOMQ), Questionnaire on Character and Values (CVQ), Questionnaire on Science as Human Endeavour (SHEQ) and Questionnaire on Metacognition and Self-Direction (MSDQ) developed from the Global Scientific Literacy Questionnaire (GSLQ) and adapted to the content of the nutrition study. Interviews were conducted to obtain in-depth information to support the outcome of the quantitative analysis. The study involved the participation of 120 form two students. A total of 10 nutrition-based SSI lesson plans were incorporated into the teaching manual. One-way ANCOVA was performed to examine changes in content knowledge on nutrition. One-way MANCOVA was performed to assess changes independent variables of habits of mind, character and values, science as human endeavour, and metacognition self-direction dimensions and their constructs. The one-way ANCOVA analysis shows a significant difference between the control and experimental groups for nutrition content knowledge. The one-way MANCOVA analysis shows significant results for overall habits of mind and the two constructs on (1) communication and collaboration and (2) systematic thinking/information management. Significant changes were obtained in the overall character and values and the two constructs on (1) ecological worldview/social and moral compassion and (2) socio-scientific accountability. Overall, science as human endeavour and the two constructs on (1) characteristics of scientific knowledge and (2) science and society/ spirit shows significant results. Too, significant outcomes were achieved for the overall metacognition and self-direction and the two constructs on (1) planning/ monitoring and (2) evaluating. The interview responses further support the significant results of the quantitative findings. The nutrition-based SSI lesson approach is new in Malaysia, especially for lower secondary students and has not been incorporated into the teaching curriculum. Therefore, a nutrition-based SSI lesson approach should be introduced into the lower secondary curriculum specification to enhance students' 21st-century science literacy.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Over four decades, significant efforts have been made to develop and shape what science literacy is about (Laugksch, 2000; Gilbert, 2003). The definition is ambiguous. Thinking 21st-century scientific literacy should move from a behavioural and cognitive viewpoint (Aikenhead, 2005) to a more inclusive diversity framework in our lives. According to Lederman et al. (2014), scientific literacy includes knowledge of science and the scientific knowledge applications in making decisions on personal and social-based problems with science and non-science components. The 21st-century scientific literacy framework has five essential dimensions of (1) content knowledge (2) habits of mind (3) character and values (4) science as human endeavour and (5) metacognition and self-direction (Choi et al., 2011). The framework is expected to encompass socio-scientific decision-making skills (Holbrook & Rannikmae, 2007) as a field beyond problem-solving on par with the development of human life from the individual to the global perspective.

Taking this into account, many science educators recommended the use of socio-scientific issues (SSI) in enhancing the five dimensions of 21st-century scientific literacy (1) the content knowledge (Sadler & Zeidler, 2005a; Sadler & Zeidler, 2005b; Yager et al., 2006; Klosterman & Sadler, 2010) (2) habits of mind (Driver et al., 2000; Kolsto, 2001a) (3) character and values (Mueller & Zeidler, 2010; Choi et al., 2013; Lee et al., 2013) (4) science as human endeavour (Sadler, 2011a; Zeidler & Sadler, 2011) and (5) metacognition and self-direction (Sutherland et al., 2010; Choi et al., 2011). SSI is new development leading to numerous moral, ethical (Lee et al., 2012), and global issues that risk humans' honour and survival. The field of health is identified as one of the areas of concern for global citizens in the 21st-century (Choi et al., 2011). Health is influenced by nutritional decisions and significantly impacted individuals and society (Cohen, 2006). More than half of all child deaths worldwide are associated with malnutrition (Mulholland & Adegbola, 2005) and nutrition-related chronic health conditions like cardiovascular disease, cancer and diabetes mellitus increase throughout the years (Murphy et al., 2017).

These emergent concerns regarding nutrition SSI give rise to a call to improve students scientific literacy to be global citizens who can overcome solve issues in a just and fair manner while moving towards a safe global community (Choi et al., 2011). Like the efforts taken by many science educators in using SSI to promote scientific literacy (Kolstø, 2001a; Sadler, 2004), in this study, an attempt was made to use nutrition-based SSI lessons to enhance the five dimensions of scientific literacy among the lower secondary school students.

1.2 Background of the study

Scientific literacy varies depending on context as well as the period it was used. (Laugksch, 2000). In the 1960s, scientific literacy emphasised inquiry and science process skills. This approach was used in science education up to the 1990s. However, there is a compelling need for science education to be re-modelled in the 21st-century (Osborne & Dillon, 2008). Scientific literacy is expected to be in line with the great globalisation of the 21st-century. The 21st-century scientific literacy should not only focus on conceptual understanding and awareness (Miller, 2004; Klop et al., 2010); indeed, there is a movement to view scientific literacy as the ability to make decisions about complex social issues that have conceptual links to science (Fowler et al., 2009). In line with the demand for change in globalisation, a new comprehensive framework has developed from the five essential dimensions: content knowledge, habits of mind, character and values, science as human endeavour and metacognition self-direction (Choi et al., 2011).

The first dimension of 21st-century scientific literacy is content knowledge. Content knowledge focuses on scientific concepts, principles and relationships among ideas needed to define and explain phenomena and issues (Choi et al., 2011). Nutrition SSIs are debatable, controversial nutrients and other substances in food-related issues which are essential in society. Since nutrition SSIs like obesity, malnutrition, climate change on the global food system, genetically modified food and plastic wastes are alarming, students are expected to comprehend the science behind those issues (Schmidt et al., 2012). Such problem solving requires knowledge of big ideas of science (Smith et al., 2006; Duschl et al., 2007; Stevens et al., 2009). Studies show that using SSI while addressing big ideas of science effectively improves understanding of science concepts related to the discussed issue (Sadler & Zeidler, 2005a; Sadler & Zeidler, 2005b; Venville & Dawson 2010; Klosterman & Sadler, 2010). Referring to obesity, the increasing number of childhood obesity shows that students have little knowledge on big ideas related to obesity "*the diversity of organisms, living and extract, is the result of evolution*" (Harlen, 2010). They could not understand the scientific concepts and the relationship between the causes and how to prevent the disease. Hence, it is essential to improve students content knowledge through a nutrition-based SSI lesson.

The second dimension in the 21st-century scientific literacy framework is the habits of mind, and it is referred to as inquiry skills in the current literacy (AAAS, 2007). Skills like problem-solving, critical thinking and informed decision-making for everyday life issues are regarded as necessary in habits of mind (Duschl et al., 2007). Studies show that SSI helps in developing students' habits of mind (Kolsto, 2001a) and its four constructs (1) communication and collaboration skills (Sadler et al., 2007; Fowler et al., 2009; Lee et al., 2012; Chung et al., 2014) (2) systematic thinking (3) the use of evidence to support claims and build arguments and (4) information management skills (Choi et al., 2011) which are vital to achieving scientific literacy (Zeidler et al., 2005). Referring to Bulimia in Malaysia, studies noticed an increasing number of eating disorder issues (Neumark et al., 2012) among adolescents (Mazubir et al., 2020). Increasing cases indicating students' acquisition of habits of mind skills needed in preventive and treatment programs (Khalid et al., 2019) are still lacking. Although habits of mind are vital for 21st-century learning (Steinkuehler & Duncan, 2008), a minimal job is done to foster school students' skills (Friedman, 2005; McDonald & Songer,2008). Hence, it is essential to improve students’ habits of mind through nutrition-based SSI lessons.

Character and values is the third dimension of the 21st-century scientific literacy framework. Three main constructs related to this dimension are (1) ecological worldview, (2) socio-scientific accountability and (3) social and moral compassion (Choi et al., 2011). Learning about the real-world and ethical debate on controversial issues has encouraged better scientific literacy forms (Zeidler & Sadler, 2008; Mueller & Zeidler, 2010). Studies have proven SSI instructions served as a practical approach to encourage the growth character and values of global citizens' (Fowler et al., 2009; Mueller & Zeidler, 2010; Lee et al., 2013) as SSI requires consideration of ethics (Lee et al., 2012) issues and the development of moral judgments (Zeidler & Nichols, 2009) on scientific issues via social engagement and discussion (Zeidler & Keefer, 2006). Referring to the issue of food waste, the rate among school children is high (UNICEF, 2018), and factors causing the problem are children's behaviour (Gustafsson et al.,2010) and unawareness of the issue (Lyndhurst, 2007). Food waste affects the environment by releasing methane and carbon dioxide gas (Abushammala et al., 2011) which causes greenhouse effects and global warming (Ventour, 2008) and problems with the availability of landfills (Hassan et al., 2001). The increasing number of cases showing the socio-scientific accountability, ecological worldview, and moral compassion values among the children and adolescents are still lacking. Therefore, students need to build a character and value system that serves as a reference to support global SSI decision-making (Hodson, 2003; Zeidler et al., 2005) that can be done through nutrition-based SSI lessons.

Science as human endeavour is the fourth dimension in 21st-century scientific literacy and there are three main constructs (1) characteristics of scientific knowledge (2) science and society and (3) the spirit of science related to it. Science as human endeavour is the awareness in their personal, social and global lives of the nature of science (NOS). One way to advance students' scientific literacy is to improve their understanding of the NOS (Allchin, 2011). NOS refers to a person's knowledge of science's social practices and organisation and how scientists collect, view, and use data to direct future study (Deng et al., 2011). NOS and SSI are interrelated, and teaching science by integrating SSI can play a vital role in the science curriculum (Levinson, 2006; Wong et al., 2011). Argumentation and discussion of different SSIs are emphasised as an essential aspect of NOS (Ogunniyi, 2006; Khishfe, 2012b). Many research studies have found gains in students' arguments when studied from the perspective of SSI (Tal & Kedmi, 2006; Walker & Zeidler, 2007). Referring to genetically modified food (GMF) in Malaysia, GMF in the food industry has created controversy, causing them to be reluctant and uncertain of accepting or rejecting GMF usage in their food production (Chi-Ham et al., 2013). Arguments on this issue show individuals lack an understanding of nutrition knowledge's characteristics, the effects of science and technology in resolving nutrition issues, and the spirit of science. Hence, it is essential to nurture science as human endeavour spirit from childhood through nutrition-based SSI lessons to promote science as human endeavour spirit among students.

The fifth dimension in 21st-century scientific literacy is metacognition and self-direction. The constructs associated with this dimension are (1) self-directed planning, (2) self-directed monitoring and (3) self-directed evaluating (Choi et al., 2011). One suggestion for improving instruction that arose from over three decades of studies on how people learn is the call for teaching metacognition (Bransford et al., 2000). Teaching approaches that emphasise student metacognitive and self-regulated learning are among the most effective approaches in promoting scientific literacy (Sutherland et al., 2010; Choi et al., 2011) and plays an essential role in ensuring global citizens who face different personal, social and global issues can work efficiently (Choi et al., 2011). Therefore, SSI is used to introduce metacognition and self-direction, which is positively associated with positive affect (Harris & Ratcliffe, 2005; Bulte et al., 2006; Albe, 2008). Referring to the refusal to eat breakfast issue among children and adolescents in Malaysia, many do not care about the importance of taking breakfast. They do not take breakfast for various excuses like no appetite in the morning and do not have time to prepare breakfast (Shariff et al., 2008). Students' denial clearly shows that they were unable to plan, monitor and evaluate their eating behaviour. They cannot consider the cause and effects of their habits, find ways to solve them and decide on them. Considering the importance of metacognition and self-direction skills to school students, nutrition-based SSI lessons were implemented to improve students' metacognition and self-direction.

When reviewing the Malaysian form two science curriculum on a nutrition topic, understanding content knowledge means understanding the basic ideas and vocabulary. However, in 21st-century scientific literacy, content knowledge is holistic with context-based scientific knowledge of core science contents. Students need to explore inside and throughout the big ideas that describe various nutritional phenomena to understand and apply them to SSIs. Therefore, to enhance nutrition content knowledge among school students, the big ideas of science on nutrition need to be emphasised in science curricula (Maučec Zakotnik et al., 2007) by introducing nutrition-based SSI lessons.

In the context of current scientific literacy, habits of mind are known as inquiry skills. In reviewing the form two science syllabus, the inquiry process involves scientific skills and thinking skills. Scientific skills used when conducting experiments and projects. However, in the 21st-century scientific literacy on habits of mind goes beyond scientific methods to skills to solve complex individual, society and global issues in a collaborative way by critically evaluating the issues, discovering and using resources, implementing core ideas, and making an argument for and against viewpoints using adequate evidence and rationalisation to support claims. Therefore, students must master skills like systematic thinking, communication and collaboration, the use of evidence to support claims, and information management.

In the context of current scientific literacy, character and values are known as attitude and motivation. In the current form two science curriculum, attitude and motivation are known as scientific attitudes and noble values. It is limited to only a few general values. However, in the 21st-century, scientific literacy, character, and values are beliefs and choices to behave responsibly concerning human life and empathy for other individuals worldwide. This system appears as a motivating factor for people to act responsibly as citizens of a technological and scientifically enlightened society and values like ecological worldview, social and morals, socio-scientific accountability and compassion nurtured in students.

Science as human endeavour in the context of current scientific literacy is known as confined silos of individuals attempting to solve critical issues and discover how science in the real world truly works. In the current form two science curriculum on nutrition topics, the element is not explicitly emphasised and placed as a value-added point under the “elements across the curriculum”. However, in 21st-century scientific literacy, science as human endeavour highlighted constructs like the characteristics of scientific knowledge, science and society and spirit of science for students to understand that scientific knowledge is human construction, theoretical-charged, evidence-based tentative, provable and imaginative. Students must realise the cooperative and integrative NOS and science's and society's interrelationship. Metacognition and self-direction is not the focus of current scientific literacy. In the current Malaysian form two science curriculum, high-order thinking skills focus on critical thinking, creative thinking, reasoning, thinking, and strategy. The emphasis is not directly on students to comprehend their own cognitive and cognition abilities to reflect the degree of knowledge they have to know if they understand or if more information is needed. Metacognition constructs like self-directed planning, self-directed monitoring, and self-directed evaluating allow individuals to review their work, look for new knowledge to address questions, and decide whether more information is required through their measures.

1.3 Problem Statement

The massive advancement of urbanisation has spurred various nutrition issues like food crisis, non-communicable diseases, nutrition disorders, genetically modified foods and many more. Overweight and obesity in children and adolescents are becoming more evident in many countries in recent years (WHO, 2016) in developing countries (Gupta et al., 2012). One in 10 children between the age of 5 to 17 are overweight or obese (WHO, 2016). In Malaysia, the Malaysian National Health and Morbidity Survey reported the rate of obesity among school children below 18 years of age was 11.9% in 2015 (IPH, 2015).

Childhood obesity also contributes to chronic health effects like cardiovascular disorders, high blood pressure, diabetes, coronary heart disease, and cancers in childhood and adulthood (Lim et al., 2012). Children with adverse dietary behaviours like breakfast skipping, reduced consumption of fruits and vegetables, junk food consumption and reduced physical activity (Lee et al., 2015; IPH, 2017) are highly exposed to malnutrition (Fadhilah et al., 2013; Tee et al.,2018). Nutrition issues could lower cognitive performance (Hoyland & Lawton, 2009; Taki et al., 2010; Prado & Dewey,2014; Jirout, 2019) and increase the risk for mental health problems like depression, emotional and behavioural problems in children and adolescents, which also affects their learning (O'Neil et al., 2014; Lee et al., 2015).

An increase in the number of issues indicating the level of nutrition literacy is alarming in society, showing that many cannot acquire, process and understand the nutritional knowledge and skills needed to make the necessary dietary decision-making (Yuen et al., 2018; Vettori et al., 2019). Many studies have shown the effectiveness of SSI-based lessons in enhancing scientific literacy in the field of environment (Zobi, 2014; Karpudewan & Roth, 2016; Zangori et al., 2017; Herman et al., 2017, 2018; Kinslow et al., 2019) and health (Dillon, 2012; Lee, 2012; Yahaya et al., 2015). However, the study on nutrition is still lacking.

On the other hand, in schools, many science teachers still practised the "chalk and talk" method to teach nutrition topics (Asmita, 2013). Studies showed that although there has been an emphasis on student-centred teaching approaches in the curricula, most classroom practices are still teacher-centred (Halim & Meerah 2016). The technique doesn't excite the students since learning draws them to the classroom (Halim et al., 2014). Besides, exam-oriented lessons (Seman et al., 2017) made teachers rush to cover the syllabus and memorise the facts (Yunus & Ali, 2018) merely. Non-issue based teaching and learning results in remarkably absent connectivity between the idea of nutrition taught and the real world (Zakaria, 2015). Furthermore, Sing and Chan (2014) discovered that teachers could not incorporate information technology into their nutrition teaching. In 2017, a new science curriculum was introduced to lower secondary students to promote a pedagogical approach to problem-solving in real-life issues (MOE, 2016; Syed Hassan & Ibrahim, 2018). Yet pedagogical approach on nutrition SSIs is still lacking (Bahrum et al., 2017; Ramli & Talib, 2017).

In Malaysia, Programmed for International Student Assessment (PISA) 2018 (Bybee, 2009) exhibited scientific literacy among Malaysian students stunted. Students could not decide, solve real-life issues, and vote deliberately about what science could do and could not do as an informed global citizen in various issues, including nutrition (OECD, 2010). Parallel studies found that students' performance is still low in habits of mind (Winnie & Arshad, 2015), character and values (Chong et al., 2016), science as a human endeavour (OECD, 2019) and metacognition and self-direction (Ibrahim & Iksan, 2017).

As changes are necessary to improve school students' awareness of nutritional scientific literacy, a nutrition-based SSI lesson was implemented to form two school students to nurture the 21st-century scientific literacy dimensions of content knowledge, habits of mind, character and values, science as human endeavour and metacognition and self-direction.

1.4 Purpose of The Study

This study measured the effectiveness of nutrition-based SSI lessons in enhancing secondary school students' 21st-century scientific literacy dimensions of (a) content knowledge (b) habits of mind (c) character and values (d) science as human endeavour and (e) metacognition and self - direction and its constructs. The study also explored students' (a) content knowledge (b) habits of mind (c) character and values (d) science as human endeavour and (e) metacognition and self–direction and its constructs on nutrition lessons.

1.5 Research Objectives

1. To explore how lessons on nutrition are taught in lower secondary science classes.

2. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' construction of big ideas of science (content knowledge) on nutrition lessons.

   2a. To explore students' big ideas of science (content knowledge) in nutrition lessons.

3. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' habits of mind on nutrition lessons.

   3a. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' communication and collaboration on nutrition lessons.

   3b. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' systematic thinking/information management on nutrition lessons.

   3c. To explore students' habits of mind on nutrition lessons.

4. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' character and values in nutrition lessons.

   4a. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' ecological worldview/social and moral compassion on nutrition lessons.

4b. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' socio-scientific accountability on nutrition lessons.

4c. To explore students' character and values in nutrition lessons.

5. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' science as human endeavour on nutrition lessons.

5a. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' characteristics of scientific knowledge on nutrition lessons.

5b. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' science and society/spirit of science on nutrition lessons.

5c. To explore students' science as human endeavour on nutrition lesson.

6. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' metacognition and self-direction on nutrition lessons.

6a. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' planning/monitoring on nutrition lessons.

6b. To evaluate the effectiveness of nutrition-based SSI lessons in enhancing students' evaluation of nutrition lessons.

6c. To explore students' metacognition and self-direction on nutrition lessons

1.6 Research Questions

The research questions are

1. How are lessons on nutrition taught in lower secondary science classes?

2. Is there any significant difference between the control and experimental group's post-test mean scores of content knowledge after controlling the pre-test mean scores?

    2a. How do students' big ideas of science (content knowledge) towards nutrition differ in pre-test and post-test interviews among experimental and control group students?

3. Is there any significant difference in the linear combination of the control and experimental group's post-test mean scores of habits of mind after controlling the pre-test mean scores?

    3a. Is there any significant difference between the control and experimental group's post-test mean scores of communication and collaboration after controlling the pre-test mean scores?

    3b. Is there any significant difference between the control and experimental group's post-test mean scores of systematic thinking/ information management after controlling the pre-test mean scores?

    3c. How do students' habits of mind towards nutrition differ in pre-test and post-test interviews among experimental and control group students?

4. Is there any significant difference in the linear combination of the control and experimental group's post-test mean scores of character and values after controlling the pre-test mean scores?

    4a. Is there any significant difference between the control and experimental group's post-test mean scores of ecological worldview/social and moral compassions after controlling the pre-test mean scores?

    4b. Is there any statistically significant difference in the linear combination between the control and experimental group's concept test post-test mean scores of socio-scientific accountability after controlling the pre-test mean scores

    4c. How do students' character and values towards nutrition differ in pre-test and post-test interviews among experimental group and control group students?

5. Is there any significant difference in the linear combination of the control and experimental group's post-test mean scores of science as human endeavour after controlling the pre-test mean scores?

    5a. Is there any significant difference between the control and experimental group's post-test mean scores of characteristics of scientific knowledge after controlling the pre-test mean scores?

    5b. Is there any significant difference between the control and experimental group's post-test mean scores of science and society/spirit of science after controlling the pre-test mean scores?

5c. How do students' science as human endeavour towards nutrition differ in pre-test and post-test interviews among experimental and control group students?

6. Is there any significant difference in the linear combination of the control and experimental group's post-test mean scores of metacognition and self-direction after controlling the pre-test mean scores?

6a. Is there any significant difference between the control and experimental group's post-test mean scores of planning/monitoring after controlling the pre-test mean scores?

6b. Is there any significant difference between the control and experimental group's post-test mean scores of evaluating after controlling the pre-test mean scores?

6c. How do students' metacognition and self-direction towards nutrition differ in pre-test and post-test interviews among experimental and control group students?

1.7 Hypothesis

Based on research questions, the following hypotheses were formulated.

1. *Hypothesis H_01*: There is no significant difference between the control and experimental group's post-test mean scores of content knowledge after controlling the pre-test mean scores?

2. *Hypothesis H_02*: There is no significant difference in the linear combination of the control and experimental group's post-test mean scores of habits of

mind after controlling the pre-test mean scores?

2a. *Hypothesis $H_0$2a*: There is no significant difference between the control and experimental group's post-test mean scores of communication and collaboration after controlling the pre-test mean scores?

2b. *Hypothesis $H_0$2b*: There is no significant difference between the control and experimental group's post-test mean scores of systematic thinking/information management after controlling the pre-test mean scores?

3. *Hypothesis $H_0$3*: There is no significant difference in the linear combination of the control and experimental group's post-test mean scores of character and values after controlling the pre-test mean scores?

3a. *Hypothesis $H_0$3a*: There is no significant difference between the control and experimental group's post-test mean scores of ecological worldview/social and moral compassion after controlling the pre-test mean scores?

3b. *Hypothesis $H_0$3b*: There is no significant difference in the linear combination between the control and experimental group's concept test post-test mean scores of socio-scientific accountability after controlling the pre-test mean scores.

4. Hypothesis *$H_0$4:* There is no significant difference in the linear combination of the control and experimental group's post-test mean scores of science as human endeavour after controlling the pre-test mean scores?

4a. *Hypothesis $H_0$4a:* There is no significant difference between the control and experimental group's post-test mean scores of characteristics of scientific knowledge after controlling the pre-test mean scores?

4b. *Hypothesis $H_0$4b:* There is no significant difference between the control and experimental group's post-test mean scores of science and society/spirit of science after controlling the pre-test mean scores?

5. *Hypothesis $H_0$5:* There is no significant difference in the linear combination of the control and experimental group's post-test mean scores of metacognition and self-direction after controlling the pre-test mean scores?

5a. *Hypothesis $H_0$5a:* There is no significant difference between the control and experimental group's post-test mean scores of planning/monitoring after controlling the pre-test mean scores?

5b. *Hypothesis $H_0$5b:* There is no significant difference between the control and experimental group's post-test mean scores of evaluating after controlling the pre-test mean scores?

1.8 Significant of Research

The nutrition-based SSI lesson promotes student-centred (Lee & Chang, 2010) and real-life learning (Simonneaux & Simonneaux, 2009; Böttcher & Meisert, 2013). The approach allows students to use scientific knowledge, define issues, make evidence-based conclusions, understand and assist in decision-making, and problem-solve nutrition SSIs as responsible global citizens (Choi et al., 2011). SSI framework acknowledges the child's epistemological growth and character development (Zeidler et al., 2005; Zeidler & Sadler, 2008) compare to the current science, technology and society (STS) framework. Hence, nutrition-based SSI lesson is an essential 21st-century learning approach in developing a holistic science curriculum for students.

In nutrition-based SSI lessons, students participate actively in groups as teachers act as facilitators to guide them. The teacher's role is complementary, to provide a social framework for scientific content understanding, research methods and reasoning skills (Zeidler & Nichols, 2009). The activity module in this study guided teachers to lead, push, facilitate, and encourage students in SSI lessons without obstructing the main involvement of the student

The study can be helpful for science education policymakers and curriculum developers. Several studies have shown SSI studies' effectiveness in enhancing environment literacy (Klosterman & Sadler, 2010; Choi et al., 2011; Lee et al., 2013; Zangori et al., 2017), yet studies on nutrition research are still lacking. Hence, this study can be a recommendation for future studies on improving scientific literacy through nutrition SSIs. The study involves a socio-cultural progressive framework (Elgström & Hellstenius, 2011; Bossér & Lindahl, 2019; Lindahl et al., 2019). It thus imparts itself with the integrative interconnection of reading skills, science content and social, which can complement recent Science, Technology, Engineering, Arts and Mathematics (STEAM) initiatives. Scientific literacy among students has proven to improve through a nutrition-based SSI lesson. Therefore, it aims to provide policymakers, curriculum developers and teachers with a reliable learning method to enhance Malaysian students' performance in Trends in Mathematics and Science Studies (TIMSS) assessment and the PISA.

These nutrition-based SSI lessons also add value to the Social Constructivism Theory and the 5E learning model used in this study. The lesson is in line with Constructivism's learning needs, which requires students to construct their learning based on their daily life experiences. On the other hand, the 5E learning model activities used in this study had improved the communication, collaboration, systematic thinking, information management, use of evidence to support claims, social and moral compassion, characteristics of scientific knowledge, the spirit of science, science and society, self-planning, self-monitoring and self-evaluating skills. Hence, this study can reference the curriculum developer who works on science education research related to Constructivism and 5E learning models.

With the increase in the level of nutrition literacy among students, it is expected the awareness of healthy eating among students can reduce nutrition-related health and learning problems like depression, stunted growth and development, cognitive impairment, greater absenteeism due to low learning performance in schools (Jacka et al., 2010; Lai et al., 2013). Ministry of Education and Ministry of Health can develop nutrition programs to help students with eating disorders, especially needy students.

1.9 The limitation of the study

This study nurtures the 21st-century scientific literacy dimensions of content knowledge, habits of mind, character and values, science as human endeavour and metacognition and self-direction through the nutrition-based SSI lesson. There were some limitations to this study. Students were chosen from form two students from one public school in Kuala Muda Yan district, Kedah. The study is limited by location and the findings may not be generalised to all Malaysian students and other countries. A wider sample from different locations can be used to generalise the study to a larger scale.

This study is limited to the five dimensions of 21st-century scientific literacy proposed by Choi et al. (2011). Other dimensions like higher-order thinking skills and Science, Technology, Engineering, and Mathematics (STEM) education can be expanded in future studies. SSI can be a useful tool for socio-scientific reasoning to improve higher-order thinking skills (Erduran & Jimenez-Aleixandre, 2007; Zeidler & Sadler, 2011). For STEM, the approach leaves a gap where specific scientific issues are needed to bring the students' culture and life experiences to the lesson. This is referred to as socio-cultural contextualisation. Contextualising the science and socio-cultural context will fill the gap and results in better STEM education (Zeidler, 2016).

This study was conducted in schools practising DLP (Dual Language Programme). The science lesson was fully conducted in the English language. DLP is a program that gives schools the option to use English in the teaching and learning of science and mathematics subjects set by the Ministry of Education Malaysia (MOE). The objective of its implementation is to support students' mastery of English language skills through increased English exposure time in science and mathematics subjects and provide opportunities for students to increase access to the exploration of various fields of knowledge to compete globally and increase student marketability in the workplace (MOE, 2018). The study can be expanded to non-DLP schools.

The study shows that a useful SSI study requires 15 weeks of intervention. A minimum commitment for just two weeks of research like a single unit lesson is insufficient for SSI learning. However, most teachers are not able to consistently feature SSI instruction over a whole semester. On the other hand, SSI learning with six-week treatment resulted in a statistically significant improvement (Kinslow et al., 2019). This study was limited to ten weeks due to time constraints to complete the syllabus. The time frame can be extended in future studies.

The lack of previous studies on the subject was another imitation faced in this study. Numerous environmental-related SSI studies conducted, yet there is a lack of nutritional SSI studies. It is, therefore, difficult for the researcher to obtain a literature review for this study. The study focuses on nutritional SSI. In future studies, it can be broadened to other SSIs like health and genetics. Next, students need to access the internet to find information related to nutrition SSIs. However, poor internet access burdens the information retrieval process. This disrupts the smooth running of the planned class, especially in terms of time management. Therefore, good internet access is necessary for the smooth operation of information retrieval. Being in the same school creates a diffusion effect since students from the same school can interact. Besides emphasising that the experiment is ongoing and encourages teachers to avoid emphasising group differences (Craven,2001). In this study, the same teacher taught the control and experimental groups to prevent the teacher's biases (Madviwalla & Hovav, 1998). The effects of the teacher were reduced with the supervision and guidance of the researcher.

1.10 Operational Definition

These are the keyword definition of this study.

Scientific Literacy: Scientific literacy, according to Miller (2007), is the knowledge of science and technology that individuals need to work as citizens in modern industrial society. Bybee (2008) described science literacy as the scientific knowledge of an individual and used it to address scientific questions, explain scientific phenomena, and make evidence-based conclusions on science-related issues. In this study, scientific literacy is referred to as the ability to use scientific knowledge, address questions and make evidence-based conclusions, understand and help in decision-making and problem-solving nutrition-based SSI as a responsible global citizen using the five dimensions of the 21st-century scientific literacy framework of (1) content knowledge (2) habits of mind (3) character and values (4) science as human endeavour and (5) metacognition and self-direction (Choi et al., 2011).

Socio scientific issues: SSIs are controversial (Yahaya et al., 2016) contemporary social issues that benefit society. The issues are science-based, requiring opinion-forming, often media-reported, addressing local, national and global perspectives. They are relevant social and political contexts, on values and ethical grounds, including consideration of sustainable growth, and requires a thorough understanding of probabilities and risks and no correct (Ratcliffe & Grace, 2003). According to Choi et al. (2011), SSI is a new development leading to numerous moral, ethical and global challenges that endanger human dignity and survival. The issues include issues on science, technology, pollution, energy shortages, pandemics, genetics, nanosciences, neuroscience, engineering, climate change and uneven health and nutritional care and provision. It is resolved only by collaborating, communicating, and cooperating among all who see themselves as part of the global community.

Nutrition SSI: Nutrition SSIs are controversial (Yahaya et al., 2016) contemporary nutrition issues that benefit society. The nutrition SSIS are science-based, requiring opinion-forming, often media-reported, addressing local, national and global perspectives. They are relevant social and political contexts, on values and ethical grounds, including consideration of sustainable growth, and requires a thorough understanding of probabilities and risks and no correct (Ratcliffe & Grace, 2003). In this study, nutrition issues like malnutrition, obesity, Atkins diet, dangers of vitamins and supplements, digestive disorders Bulimia Nervosa, alkaline water, anaemia, vegetarianism, Genetically Modified Foods and danger of plastic water bottles and food containers and Bisphenol-A (BPA) used as a tool to promote the five dimensions of the 21st-century scientific literacy: content knowledge, habits of mind, character and values, science as a human endeavour, and metacognition, and self-direction.

Big Ideas of Science: Big ideas of science allows students to predict phenomena and solve issues related to science and society (Linn & Eylon, 2006) and form the basis for future learning. Big ideas include the matter particle nature, ecology, processes and interactions, patterns of change, energy, sustainability, scale and structure, and evolution and equilibrium (OECD, 2004; NRC, 2010). In this study, students will use different ideas to predict phenomena and resolve nutritional SSI issues by combining all the main ideas. Harlen (2010) proposed fourteen big ideas of science.