THE EFFECTS OF SOCIOSCIENTIFIC ISSUES WITH THINKING WHEEL MAP APPROACH ON CURIOSITY TOWARDS STEM OF YEAR FIVE STUDENTS

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Abstract

This research was conducted to examine the effects of the socioscientific issue with the thinking wheel map (SI-TWM) approach on the curiosity towards STEM, the construct of Exploration and Acceptance. A teaching and learning (TL) module was developed to guide teachers in implementing the SI-TWM approach to enhance curiosity among year five students. Quasi-experimental quantitative research was conducted on 345 year five students (aged 11 years old) in urban primary schools in Tawau, Sabah, Malaysia. A total of three groups were assigned randomly, namely i) socioscientific issue with thinking wheel map approach (SI-TWM, n=115), ii) socioscientific issue approach (SI, n=115), and iii) conventional approach (CONV, n=115). The curiosity towards STEM questionnaire was developed to measure the level of curiosity towards STEM. Data analysis was performed using MANCOVA, ANCOVA, and effect size. The results of the MANCOVA analysis showed that there was a significant effect across the three TL approaches for curiosity towards STEM. Meanwhile, the ANCOVA analysis results showed a significant effect of the SI-TWM approach compared to the SI and CONV approaches on curiosity towards STEM, the construct of Exploration and Acceptance. The results of this research prove that the SI-TWM approach positively impacts the cultivation of students' curiosity towards STEM.
Keywords: *curiosity towards STEM, socioscientific issue, thinking wheel map, year five students*

Introduction

Curiosity is necessary to deal with the increasingly complex problems in daily life and help provide students with the skills needed to face the 21st-century world. According to Kashdan et al., (2004), curious students explore new strategies and ideas, learn the skills needed to conduct inquiry and research, show independence in learning, and continuously enjoy lifelong learning experiences. Basically, curiosity is a positive emotional experience (Silvia, 2006). In science education, curiosity makes learning more meaningful and helps achieve targeted objectives (Ball, 2013). Likewise, a creator needs to have thought based on scientific knowledge and curiosity. A creator driven by curiosity will better understand a problem from various angles and be able to solve problems effectively (Jeraj & Marič, 2013). In addition, the questions that arise from curiosity will encourage an inventor to produce the best product (Peljko et al., 2016).

Realizing the importance of curiosity, the Malaysian Ministry of Education has taken pragmatic steps by emphasizing curiosity in the learning curriculum. The Malaysia Curriculum Development Division (2014) has outlined curiosity as one of the profiles of students who want to be born through 21st-century learning and is included in one of the Scientific Attitudes and Pure Values. This quality is so important that it is the main objective in formulating the elementary school science curriculum. Although curiosity is seen to have an important effect on student learning, motivation, and creativity (Gurning & Siregar, 2017; Renninger et al.,

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2019; Shenaar-Golan & Gutman, 2013), studies on curiosity among school students have not yet been comprehensive (Renninger et al., 2019). Therefore, Renninger et al. (2019) suggested that relevant pedagogy should continue to be developed because it can increase curiosity and positively impact learning. This proves the need to develop a learning module that can help in increasing students' curiosity.

Based on the discussion above, the infusion of curiosity needs to be started at a lower level through a medium that can drive students' knowledge and creative skills, which is STEM education. This statement is supported by a study by early childhood education experts who state that STEM education should start in preschool and elementary school (Katz, 2010). The findings of previous studies show that exposure to STEM at an early stage can: (a) build the foundation for learning and the development of children's minds in the future; (b) assist in the development of critical thinking and reasoning skills; (c) increase children's interest in learning Science and Mathematics, and interest in STEM-related careers; (d) develop curiosity, love to ask and love to investigate; and (e) give children a broad experience of the natural and artificial world around them (Bybee, 2013; Hoachlander & Yanofsky, 2011; National Research Council, 2011). Even though the implementation of STEM has begun to be implemented in the school curriculum, the research conducted on the curiosity of students towards STEM in Malaysia has not yet been widespread (Buang et al., 2009; Syukri et al., 2013). Therefore, in the context of this research, the researcher applies the use of the learning module that has been developed as a medium to increase curiosity through STEM education.

A person must have a deep curiosity to achieve good creative skills. However, the fact is that there are still gaps and constraints in producing curious students. Through analysis in the Classroom Assessment Mastery Achievement Report (CAMAR) (Tawau District Education Office, 2019), the researcher found that one of the reasons for the low percentage of Level Six (L6) mastery is the lack of curiosity among students. In order to get further clarification on this matter, the researcher interviewed two School Improvement Specialist Coaches Plus (SISC+) officers who supervise Science subjects in the Tawau district in Room X on 14 January 2020, at 2.15 pm. Based on the two SISC+ officials interviewed, they agreed that the low achievement of students in Level Six (L6) mastery in CAMAR is due to the lack of curiosity among students. They stated that through monitoring and interviews with science teachers in several primary schools in urban areas, most science teachers stated that students lacked the desire and curiosity to create a product. Without curiosity, students do not show interest in trying to create a product. For example, in the Science Theme of the Animal Protection Unit, students have to create an imaginary animal with some protective features that can protect the animal from predators and extreme weather as a project that needs to be completed at home. However, based on teachers' feedback, only a few students sent their creations. This clearly shows that students in primary schools in urban areas have a low level of curiosity.

Interviews with SISC+ officers of the Tawau District Education Office also confirmed that the increase in the level of student creation is linked to the level of student curiosity. This is proven by Jeraj and Marič (2013), who stated that in creating a product, curiosity would act as a catalyst in encouraging students to create. In addition, the interviews were supported by a needs analysis conducted by the researcher, who found that the science teachers interviewed did not have an explicit approach of cultivating curiosity among the year five students. In addition, the teachers who were interviewed also stated that there is no guide or teaching module that can be referred to in increasing curiosity among year five students.

This scenario leads to a consensus that there is a need for effective pedagogy in increasing curiosity among year five students. Through a study conducted by Birmingham and Barton (2014); Maloney and Simon (2006); and Nam and Chen (2017), the socioscientific issue (SI) approach is the preferred approach in solving science, technology, and societal issues. The SI approach is seen to help improve students' scientific knowledge (Driver et al., 2000; Kinslow &

Sadler, 2018; Sadler et al., 2017; Topcu et al., 2018; Zeidler et al., 2009). Scientific knowledge generated through the debate of socioscientific issues encourages students to generate ideas more effectively in creating a product. The ideas generated, developed and refined during the discussion of socioscientific issues will lead to more systematic creation skills. Not only that, but students can also relate the results of their creative contributions to solving problems in society.

However, the researcher finds that the discussion of issues through debate and argumentation alone is less effective in fostering curiosity. As suggested by Birmingham and Barton (2014) and Maloney and Simon (2006), the infusion of SI and thinking wheel maps (TWM) can develop students' argumentation skills and science knowledge. The TWM used in this research was inspired by Bloom (1956) and adapted from Glenn (1972) and Bengston (2016). The TWM is a thinking tool used in groups through a structured brainstorming process to determine the impacts of changes at various levels (Bengston, 2016). In relation to that, STEM is seen as an effective platform for realizing SI pedagogy with the help of TWM. This is because STEM education can provide space for students to learn realistically (Tsupros et al., 2009) and face the challenges of everyday life related to STEM fields (Bybee, 2013). Studies also found that STEM Education can improve Science literacy and engineering design skills that are needed to produce a generation of inventors (Afriana et al., 2016; Committee on STEM Education, 2018; Jin & Bierma, 2013; Kennedy & Odell, 2014; McDonald, 2016; Zollman, 2012). In fact, the interdisciplinary approach in STEM education helps students master science and mathematics based on technology and engineering. Thus, there is a need to conduct a research study on the socioscientific issues with the thinking wheel map approach as well as to evaluate its effects in increasing year five students' curiosity towards STEM.

Literature Review

Curiosity

Literally curiosity is defined as the desire within a person to obtain new information without expecting appreciation or extrinsic factors (Raharja et al., 2018). According to Shiau and Wu (2013), curiosity is a desire and type of intrinsic motivation to know, understand or experience that gives rise to exploratory behaviour to obtain new knowledge. Curiosity will encourage a student to process information in more detail, remember information better, and complete tasks more efficiently (Kashdan et al., 2009). Individuals with curiosity will always seek new knowledge and experience. Coinciding with that, Kashdan et al. (2009) suggested that curiosity be measured based on two constructs, namely Exploration and Acceptance. Exploration refers to the motivation to gain new knowledge and experience, while Acceptance refers to the willingness to accept something original, uncertain, and unexpected in everyday life. The definition of the two constructs of Exploration and Acceptance by Kashdan et al. (2009) is based on Berlyne's Theory of Inquisitiveness.

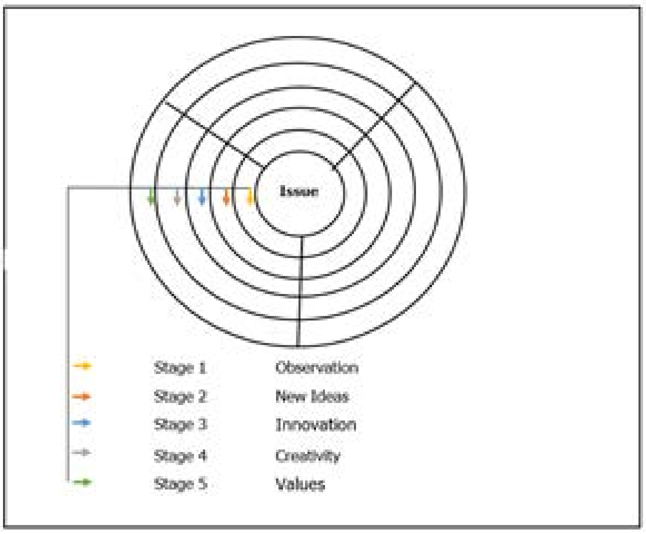
Socioscientific Issues Approach

The socioscientific issue (SI) approach requires students to make decisions about social issues that involve moral implications in a scientific context (Sadler, 2004; Zeidler et al., 2003; Zeidler et al., 2005). At the same time, the application of the SI approach is also proven to help foster curiosity among students. Curiosity arises because of the need to relate knowledge to real situations. Through discussing socioscientific issues that occur in everyday life, students are given space to connect and apply Science knowledge in the environment outside the classroom (Ainsworth et al., 2011; Prain & Tytler, 2013). Fowler et al., (2009) stated that the SI approach helps increase students' moral awareness. Indirectly, students' curiosity can undoubtedly be generated because the knowledge of students' issues will influence their behaviour and opinions expressed during socioscientific issue debates, person's point of view and personality (Lewis & Leach, 2006).

Thinking Wheel Map

Thinking Map (TM) is often used as a thinking tool that can improve cognitive abilities such as understanding, analysing, solving problems, and presenting information in visual form (Oxman, 2004). Furthermore, TM helps students understand concepts, analyse problems, and find solutions (Hyerle & Yeager, 2007). In this research, the researcher used the thinking wheel map (TWM) inspired by Bloom (1956) and adapted from Glenn (1972) and Bengston (2016) (Figure 1). This TWM is a thinking tool that helps students identify the implications of a change. TWM is used in groups through a structured brainstorming process to determine changes' impacts at various levels (Bengston, 2016). The TWM was divided into the centre of the wheel and five levels of the wheel (Figure 1) that helped students generate and organize their ideas. During the use of this module, students were given socioscientific issues to discuss and argue. At this time, any logical and scientific ideas were written in the centre of the map. These ideas were the trigger ideas for students to solve in the next stage. Then, students wrote their ideas at each level according to the constructs of Observation, New Ideas, Innovation, Creativity, and Values.

Figure 1
Thinking Wheel Map



Source: Adapted from Bloom (1956), Glenn (1972) & Bengston (2016)

Aim

This research was conducted to determine the effects of the socioscientific issue with the thinking wheel maps (SI-TWM) approach in fostering curiosity towards STEM among year five students compared to the socioscientific issue (SI) and conventional (CONV) approaches. This research used three intervention approaches: SI-TWM, SI, and CONV. The operational definition of curiosity towards STEM refers to the construct adapted from the study of Kashdan et al. (2009), namely Exploration and Acceptance. Specifically, this research aimed to determine the effects of the SI-TWM approach compared to the SI and CONV approaches on curiosity towards STEM and the Exploration and Acceptance construct.

Research Methodology

Design

The research employed a quasi-experimental pre-test and post-test control group design. The independent variable was the three TL approaches: the SSI-TWM (Experimental group), and SSI (placebo group), and the CONV (control group). Dependent variables are based on students' attainment of curiosity towards STEM and the constructs of Exploration and Acceptance. The research lasted three months, from January 2021 to the following March.

Sample

A purposive sampling technique was employed in this research. A total of 345 year five students from four urban primary schools were involved as research samples, comprising of 186 (54 %) females and 159 (46 %) males aged 11 years old. The schools were selected based on criteria such as the number of classes in the school, socioeconomic background, cultural diversity, and the level of academic performance of students in a school. In each school, three groups of students were involved and randomly assigned to the SSI-TWM approach, the SSI approach and the conventional (CONV) approach. In total, each group of SSI-TWM, SSI, and CONV has 115 students. Prior to the research, students were given a letter of consent detailing the nature of their involvement in the research. The research aim was explained, and students were assured of anonymity and the confidentiality of their response.

Teaching and Learning (TL) Approach

The teaching and learning (TL) approach is divided into three types, namely the socioscientific issue with the aid of the thinking wheel map approach using the SI-TWM module (Ahmad & Siew, 2021a), the socioscientific issue approach (SI), and the conventional approach (CONV). In the SI-TWM TL approach (Treatment Group 1), students were exposed to socioscientific issues with the help of thinking wheel maps, building sketches and prototypes and are student-centred. Students in groups are asked to discuss and work together to complete the three assigned missions. In Mission 1, students are asked to discuss and argue about the socioscientific issues given. The following is an example of a socioscientific issue.

> *'Tawau is a developing city. However, the issue of electricity supply being cut off in Tawau is not a new thing. This always happens as a result of electricity theft or illegal electricity connection in slum housing areas. As a result, the affected areas will experience power outages. This causes difficulty in doing any activity in the house that requires light.*
> *The question is, is it appropriate to use lamps as a source of light in residential houses in Tawau?'*

Students then write their arguments and opinions in the centre of the thinking wheel map. In Mission 2, students are asked to discuss future model designs. Brainstorming results are written in the subsequent levels of the thinking wheel map. The final result needed to be sketched on A3 paper. In Mission 3, students are asked to construct and present their prototypes in front of the class. Meanwhile, the SI approach acts as Treatment Group 2, where students are exposed to socioscientific issues without the help of wheel thinking maps, build sketches and

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prototypes, and are student-centred. Next, for the CONV approach, students are asked to build sketches and prototypes and be student-centred without using the SI-TWM module.

Curiosity towards STEM Questionnaire

In this research, the Curiosity towards STEM Questionnaire instrument (CU-STEM) was developed. CU-STEM has evidence of good construct validity and reliability assessed using the Rasch Measurement Model based on the findings of a pilot study involving 166 students (Ahmad & Siew, 2021b). The CU-STEM instrument was adapted from Kashdan et al. (2009) to measure students' curiosity. The CU-STEM instrument contains two constructs and ten items: 1) Exploration (5 items) – Example: "I see challenging situations in STEM as opportunities to learn."; and 2) Acceptance (5 items) – Example: "Everywhere I go, I find new things or experiences about STEM.". It is a 5-point Likert Scale instrument, where 1 refers to "Strongly Disagree", 2 "Disagree", 3 "Neutral", 4 "Agree", and 5 "Strongly Agree". The validity of the CU-STEM instrument was also assessed based on the analysis of the construct validity of the items in the Rasch Measurement Model. Findings from the assessment of item fit in Rasch analysis indicate that all items in the CU-STEM instrument also meet at least one criterion for Outfit MNSQ, Outfit ZSTD and PT-MEASURE CORR as stated by Sumintono and Widhiarso (2015). This shows that the items in the CU-STEM instrument are suitable for use on the research sample. In addition, the reliability of the CU-STEM instrument, which was also analysed using Rasch analysis, reported good index values for item reliability (.96) and respondent reliability (.93).

Data Analysis

The data obtained from the CU-STEM instrument were analysed descriptively and inferentially using SPSS software version 26. For descriptive analysis, the mean value for each construct and the whole was calculated using the scale recommended by De Vaus (2002), where the mean classification was determined according to the level of low, medium, and high by dividing the full value of each construct into three parts according to the research context. Table 1 shows the level of analysis and interpretation of the mean in this research.

Table 1
Level of Mean Analysis and Interpretation of Mean

Level	CU-STEM construct	CU-STEM
Low	5.00 – 11.67	10.00 – 23.33
Medium	11.68 – 18.35	23.34 – 36.67
High	18.36 – 25.00	36.68 – 50.00

For inferential analysis, multivariate analysis of variance (MANOVA) was used to compare the mean score obtained from the pre-test. Multivariate Analysis of Covariance (MANCOVA) was used to evaluate the effect of three different teaching and learning (TL) groups on curiosity towards STEM. Independent variables identified in previous research as valid predictor variables of dependent variable outcomes can be used as covariates (Field, 2018). Therefore, this research identified three covariates, namely pre-CU-STEM, pre-Exploration, and pre-Acceptance. This covariate served as a control variable for TL groups, adjusting for possible differences between groups. If the overall MANCOVA results were statistically significant, then a series of Univariate Analysis of Covariance (ANCOVA) was performed to determine the significant effect of TL groups on each dependent variable.

The next step of statistical analysis is if the ANCOVA results are statistically significantly different in the three TL groups, a post-hoc comparison technique is performed to determine which group is significantly different compared to the other group for each dependent variable. The significance level was set at $p < .05$, meaning there is a difference between the research groups. The preliminary analysis was carried out where the prerequisite assumptions of the MANOVA/MANCOVA, namely the identification of outliers, normal distribution, equality of covariance, linearity of variables, multicollinearity, and homogeneity of variance must be met before testing multivariate statistical findings (Tabachnick & Fidell, 2019). All prerequisite assumptions of MANOVA/MANCOVA have been fulfilled except the assumption of the equality of covariance, where the assumption of the equality of matrix in this research was violated in the CU-STEM pre-test [Box's $M = 20.576$, $F(6, 2868114.40) = 3.400$, $p < .01$] as well as the CU-STEM post-test STEM STEM [Box's $M = 17.106$, $F(6, 2868114.40) = 2.827$, $p < .01$]. Grice and Iwasaki (2007) emphasized that violations of equality of covariance are common and easily be overcome by using Pillai's Trace. In addition, the effect size (d) is also used in this research to measure the strength of the effect and provide important information in the statistical analysis regarding the value suggested by Cohen (1998).

Research Results

Table 2 shows a comparison of the pre-test and post-test levels of curiosity towards STEM (Cu-STEM) along with its two constructs, namely Exploration and Acceptance. An increase in the mean score level, from a medium level to a high level is found for Cu-STEM and both Exploration and Acceptance constructs in the SI-TWM group. Meanwhile, for the SI group, the increase in the mean score level from medium to a high level is seen only in the Acceptance construct. The mean score level for the CONV group remained at a moderate level.

Table 2

Comparison of Mean Score Levels for CU-STEM and Constructs in Pre-test and Post-test

Construct	TL approach	*N*	Pre-test			Post-test		
			M	*SD*	Level	*M*	*SD*	Level
CU-STEM	SI-TWM	115	30.34	2.979	Moderate	39.83	3.053	High
	SI	115	3.77	3.327	Moderate	35.11	3.363	Moderate
	CONV	115	30.57	2.675	Moderate	32.59	2.685	Moderate
Exploration	SI-TWM	115	14.50	2.023	Moderate	18.88	2.272	High
	SI	115	14.58	2.009	Moderate	16.72	2.071	Moderate
	CONV	115	14.81	1.696	Moderate	15.68	1.838	Moderate
Acceptance	SI-TWM	115	15.83	2.099	Moderate	20.95	2.077	High
	SI	115	16.19	2.251	Moderate	18.39	2.118	High
	CONV	115	15.79	1.775	Moderate	16.91	1.684	Moderate

Through MANCOVA analysis, Pillai's Trace multivariate test results (Table 3) show that overall there is a significant effect of independent variables (TL approaches) [$F(4, 678) = 56.394$, $p < .05$] on curiosity towards STEM. However, there was no effect of the control variable or covariate (pre-CU-STEM) on the dependent variable of curiosity about STEM [*F*

(2, 338) = 1.011, $p > .05$]. The same findings were also obtained on the construct of curiosity towards STEM, where there was a significant effect of TL approaches [$F(4, 678) = 56.394$, $p < .05$] on the post-Exploration and post-Acceptance constructs. However, there was no effect of the control variables or covariates (pre-Exploration and pre-Acceptance) on the dependent variables of the constructs post-Exploration [F (2, 338) = .245, $p > .05$] and post-Acceptance [$F(2, 338) = .075$, $p > .05$] respectively. This shows that by controlling the covariate variables, TL approaches are factors that contribute to the acquisition of curiosity towards STEM and the acquisition of the Exploration and Acceptance construct. Further, an ANCOVA test analysis was conducted to identify whether there was an effect of the independent variable (TL approaches) on the dependent variable, which was curiosity towards STEM, the construct of Exploration, and Acceptance. ANCOVA analysis showed that there was a significant effect of TL approaches on curiosity towards STEM [$F(2, 341) = 163.870$, $p < .05$, η2 = .490], Exploration [$F(2, 341) = 71.066$, $p < .05$, η2 = .294], and Acceptance [$F(2, 341) = 123.175$, $p < .05$, η2 = .419]. A high relationship was found between the TL approach, with the dependent variable showing that 49.0% (curiosity towards STEM), 29.4% (Exploration), and 41.9% (Acceptance) of the variance obtained was accounted for by the SI-TWM TL approach.

Table 3
Results of the Multivariate MANCOVA and Univariate ANCOVA Tests and Covariates of curiosity towards STEM

Effect	MANCOVA			ANCOVA			
	Pillai's Trace *F*	*df*	*p*	*F*	*df*	*p*	Partial ETA Square (η^2)
TL approach	56.394	4, 678	$p < .05$	163.870	2, 341	$p < .05$	.490
Pre-CU-STEM	.011	2, 338	.989	2.289	1, 341	.131	.007
TL approach	56.394	4, 678	$p < .05$	71.066	2,341	$p < .05$	.294
Pre-Exploration,	.245	2, 338	.783.	.423	1, 341	.516	.001
TL approach	56.394	4, 678	$p < .05$	123.175	2, 341	$p < .05$	.419
Pre- Acceptance	.075	2, 338	.928	.186	1, 341	.666	.001

Table 4 shows the results of post-hoc pairwise comparison and effect sizes for the effects of TL approaches on CU-STEM, along with the Exploration and Acceptance constructs. The post-hoc pairwise comparison shows that the SI-TWM approach is significantly higher than the SI approach for the entire CU-STEM as well as all constructs in the CU-STEM ($p < .05$). Meanwhile, the pairwise comparison also shows that the SI-TWM approach is significantly higher than the CONV approach for the entire CU-STEM and all constructs ($p < .05$). The same finding is also obtained in the pairwise comparison between the SI and CONV approaches, where the SI approach is significantly higher than the CONV approach for the entire CU-STEM as well as all constructs in the CU-STEM ($p < .05$).

Table 4

Post-Hoc Pairwise Comparison Results, Mean Difference (MD) and Effect Size (d)

Construct	Pairwise Comparison	*MD*	*p*	*d*	Interpretation **(Cohen, 1988)**
CU-STEM	SI-TWM vs SI	4.678	$p < .05$	1.46	Big
	SI-TWM vs CONV	7.180	$p < .05$	2.52	Big
	SI vs CONV	2.502	$p < .05$	.83	Big
Exploration	SI-TWM vs SI	2.166	$p < .05$	.99	Big
	SI-TWM vs CONV	3.189	$p < .05$	1.55	Big
	SI vs CONV	1.023	$p < .05$	.53	Moderate
Acceptance	SI-TWM vs SI	2.569	$p < .05$	1.22	Big
	SI-TWM vs CONV	4.041	$p < .05$	2.14	Big
	SI vs CONV	1.471	$p < .05$	.77	Moderate

For the effect size analysis, in the CU-STEM aspect as a whole, students who were exposed to the SI-TWM approach showed a large effect size compared to the SI approach ($d = 1.46$). In addition, a large effect size was also seen in the comparison between the CONV approach with the SI-TWM ($d = 2.52$) and SI ($d = .83$) approaches. As for the CU-STEM construct, the same findings can also be seen on all the constructs in CU-STEM except for the mean pair comparison between the SI and CONV approaches. In this regard, the SI approach shows a moderate effect size compared to the CONV approach on the Exploration ($d = .53$) and Acceptance ($d = .77$) constructs. Statistically, it can be concluded that the SI-TWM approach is effective in increasing the year five students' curiosity towards STEM and the Exploration and Acceptance construct.

Discussion

The acquisition of curiosity towards STEM has shown that the mean score for the SI-TWM approach is significantly higher than the SI and CONV approaches. In this regard, the SI-TWM approach, which highlights socioscientific issues with the thinking wheel map approach, motivates students to explore new STEM knowledge. In the context of this research, the SI-TWM module was used as an intervention in the SI-TWM group highlights unique issues that are overcome openly and in the form of issue-based solutions (Owens et al., 2017; Topçu et al., 2018). In the application of the SI-TWM intervention, the socioscientific issue approach, with the help of a thinking wheel map, will encourage students to debate to find answers to the uncertainties and impasses that occur and help organize ideas and answers in a more structured and systematic way (Utami & Subali, 2020). At the same time, the study of Utami and Subali (2020) also proved that using certain teaching approaches or pedagogy with the help of a thinking wheel map can increase the level of curiosity of students statistically.

The increase in the mean score of the Exploration construct for students who followed the SI-TWM approach compared to SI and CONV proves that the application of SI-TWM is also proven to help foster the nature of exploration among students. In addition, the use of SI-TWM intervention provides space for students to explore to obtain new information and knowledge (Stare et al. 2018) and record the information so that it is easier to be referred (Hyerle & Yeager, 2007). In the context of this research, the SI-TWM approach can act as an external stimulus that encourages the emergence of curiosity. Curiosity arises because of the need to relate knowledge to real situations. Through discussing socio-scientific issues that occur in everyday life, students are given space to connect and apply Science knowledge in an environment outside the classroom (Prain & Tytler, 2013). Previous studies have also shown that curiosity through exploration increases learning and longer retention of information in children (Walin et al., 2016). Stare et al. (2018) prove that the increase in memory is influenced by the desire to explore knowledge. This is because curiosity will encourage the desire to explore and find new knowledge to reduce uncertainty.

In the improvement of the Acceptance construct, exposed socioscientific issues encourage students to build new stimuli and opportunities. Berlyne's Theory of Inquisitiveness coincides with the context of this research, where students were given socioscientific issues to discuss and solve through the process of generating ideas through a thinking wheel map. As a result, mastery of the Acceptance construct also increases and helps in student development (Dubey et al., 2019). Using the SI-TWM approach increases students' willingness to accept new and original things. Pupils who accept new, original and unexpected things have more extensive knowledge (Kashdan et al., 2009). In the study of Kashdan et al. (2018), this dimension has the second highest relationship with a person's personal development. Furthermore, accepting the unexpected opens space for students to think of abstract and complex ideas, solve problems and find relevant information to eliminate the uncertainty that arises (Piotrowski et al., 2009). Pupils are more open to accepting new, unexpected, complex and mysterious things to build motivation to overcome doubts and confusion that occur.

Learning via SI-TWM approach implies that students have to dare to explore to gain new knowledge and experience in STEM. Openness in accepting something original, uncertain and unexpected in everyday life will provide a wider platform for students to develop themselves in STEM. This is because students will try various activities on the basis of curiosity. In essence, students will be more knowledgeable and have skills in various fields not only STEM fields.
The infusion of teaching and learning approaches with thinking wheel maps turned out to have a significant effect on the cultivation of curiosity about STEM. Module developers are suggested to integrate these two aspects in the development of science modules. In this case, module developers can use this approach as a basis in the production of modules that focus on improving students' affective behaviour such as curiosity and motivation. Students will raise questions about the concept of what is happening and how to solve it. In addition, the module developers also need to ensure the socioscientific issues chosen are suitable for the level of the students and relevant to their daily lives.

Conclusions and Suggestions

The results of the research have shown a significant positive effect of the SI-TWM approach compared to SI and CONV in increasing the curiosity towards STEM and the Exploration and Acceptance construct. Overall, the affective effect obtained shows that the implementation of SI-TWM approach is better than the SI and Conventional approaches. This proves that the infusion of SI and TWM teaching and learning approach in the teaching and learning process can increase the students' curiosity towards STEM.

This research focuses on the effect of SI-TWM approach on curiosity towards STEM through the infusion of socioscientific issue and thinking wheel map approach for year five students from urban primary schools. Therefore, for future research, researchers are suggested to conduct infusion approach among secondary school students which will provide variation from gender and school location differences. This study only involves the theme of Physical Science as well as Technology and Sustainable Living. Therefore, it is suggested that future researchers can fill the gaps by involving other themes that have socioscientific issues to be highlighted.

This research provides findings through a quantitative approach that shows the effects of SI-TWM approach statistically through the difference in pre-test and post-test mean scores. Therefore, in further research it is suggested that qualitative data be collected through observation, interviews, and document analysis of student work. Through qualitative methods, a deeper exploration of how SI-TWM approach plays a role in improving each construct can be refined. This can certainly strengthen the findings from the quantitative data.

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Declaration of Interest

The authors declare no competing interest.

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