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Abstract

This study investigated the use of interdisciplinary learning activity task to construct students' knowledge in Mathematics, specifically on the topic of scale drawing application. The learning activity task involved more than one academic discipline, which is Mathematics, English Language, Art, Geography and integrating the Brunei Darussalam national philosophy of the Malay Islamic Monarchy. A quantitative method using a pre-experimental design focusing on one-group pre- and post-test design was used for this study. The participants were selected from a convenient sample of 43 Year 9 students in one of the secondary schools in Brunei. The findings were also triangulated with the students' collected reflective journal artifact documents. Each student journal was analyzed using the identified learning activity stages within the RBC-model, where the R denotes *Recognizing*, B is *Building with* and C means *Constructing*. The results showed an improvement in the students' achievement, and they were able to construct the mathematics knowledge by means of collaboration among group members. Based on the findings, it is recommended that Mathematics teachers be encouraged and supported to design authentic and interdisciplinary learning activity that are learner centered catering to the different needs of our students and also to meet the 21st century skills demand.

Introduction

With the introduction of the current education system known as SPN21, which is the acronym for *Sistem Pendidikan Negara Abad ke-21*, and translated to the English Language, the National Education System for the 21st century of Brunei Darussalam, significant changes were made to reform the country's education system (Ministry of Education, 2013). The SPN21 aims to make three significant changes. Firstly, the structure of the current education system; secondly, developing a more balanced curriculum that emphasised assessment for learning; and thirdly, making changes and adjustment of the technical education to be in line with the 21st century requirements (Department of Planning, Research and Development, 2012). Several ongoing initiatives have been implemented to advocate the continuous successfulness of SPN21. One of the ongoing initiatives was the implementation of the School Based Assessment *for* Learning (SBA*fL*) that give teachers autonomy to plan, develop, implement and adapt the designed classroom assessment based task with specific learning outcomes criteria and rubrics to cater for the different needs and skills of the students (Curriculum Development Department, 2012).

Additionally, the SPN21 curriculum aimed to mould the students to become an intellectual, spiritual and physically balance whole rounded person (Ministry of Education, 2013). The intended learning outcomes for mathematics are for the students to develop the essential learning skills of a concept by developing the students mathematical thinking and reasoning through understanding, interpretation and communication both in the form of speaking and written format. With the correct attitudes and appreciation of the nature of mathematics and the mathematical processes these can boost the student's confidence in mathematics in their daily life needs (Ministry of Education, 2013).

In addition, Kidron and Monagahan (2009), and Taale (2013) recognized the impact of various learning activities on students' abilities to construct their own knowledge for their academic performances and achievement. This was further proven from findings of research carried out and reported by Dreyfus (2012) using an earlier developed framework (Hershkowitz et al., 2001; Schwarz et al., 2009), on the effectiveness of teachers' designed learning activities for students to construct knowledge. However, several concerns and complications with SBA*fL* arose due to the fact that students and teachers were more familiar with the traditional summative assessment systems (Curriculum Development Department, 2012). It is a global issue

among educators and researchers as there is a demand to increase the level of accountability of the teachers. Additionally, the issue on the need to support the quality of the teacher's classroom instructions to move away from the conventional assessment into authentic assessment (Koh & Velayutham, 2009; Adolsary, 2010; Fazekas, 2011; Koh et al., 2012; Taale, 2013; Nor & Shahrill, 2014; Nawi et al., 2015; Othman et al., 2015; Caesar et al., 2016; Chong & Shahrill, 2016).

After several decades of researches on human learning and performance, Resnick (1987) concluded that using traditional assessment failed to measure the validity of students' higher order thinking skills and the preparation to the real-world problem tasks. A quasi experiment study was conducted over two years in Year 4 and Year 5 classes in Singapore schools on teacher's assessment task interventions in literacy subjects, such as English, Chinese, Science and Mathematics. From the experiment it was proposed that Mathematics was a subject that emphasised on factual and procedural knowledge type of understanding. The findings also revealed that the mean scores for the teachers' assessment task and the quality of the students' work through rubrics design, showed substantial improvements in all the subjects except for Mathematics (Koh & Velyutham, 2009).

The research conducted by Shear, Gallagher et al. (2011) on Innovative Teaching and Learning (or ITL), listed several critical gaps in education, such as the skills that the students learned in school and the preparations of the essential life; work skills to prepare the students for their future demand life and requirement of the career field. Based on the findings, teachers need to make changes and move away from the single type of instruction into a differentiated approach of instructions to meet the expectations of the 21st century students' diverse needs. The 21st century classroom is evolving into something more dynamic and interestingly more futuristic. In Brunei Darussalam, the SPN21 curriculum has been paying attention to the pedagogical approach of 'Fun, Play and Learn More' in its support to student centred learning, diversity in the teaching methods, and the techniques to be aligned with the integration of Brunei Darussalam national philosophy of Malay Islamic Monarchy (or *Melayu Islam Beraja* in the Malay Language and abbreviated as MIB).

Literature Review

Educators and leaders around the world have acknowledged the vital importance to prepare our younger generations for the 21st century. Educational transformation processes are essentially complex. Microsoft together with the Partners in Learning Program have given its full commitment by introducing the ITL Research project globally, aimed to look into the factors that support the evolution of teaching practices and the effects on students' learning outcomes (Langworthy et al., 2010). Langworthy and colleagues and a team of researchers from the ITL 21st century Learning Design (21CLD) developed a program to expose teachers to the practical ways of incorporating the 21st century skills in their teaching. By collaborating to design new learning activity, analyzing and 'coding' the learning activity can provide teachers to have an insight of the development to integrate 21st century skills. Using Information Communication and Technology (ICT) as part of the learning processes can help teachers to be learners of their own teaching practices, and to investigate the effectiveness of the design learning activity on students' work. Based on international feedback with Creative Common license, ITL research and Microsoft Partners in Learning have improved the 21CLD rubrics for Learning Activity (LA). The intention of the 21CLD rubrics acts as a guideline for the teachers to identify and understand the possible opportunities that learning activity can give students in order to construct the 21st century skills. The SRI International (2012) has designed six rubrics of the 21st century learning based on international feedback. Each rubric represents important 21st century skills for students to develop, such as collaboration, knowledge construction, self-regulation, real-world problem solving and innovation, the use of ICT for learning, and skilled communication. For this present study, we focused on the knowledge construction skills based on the teacher's designed learning activity.

A learning activity is defined as any learning academic task that a teacher designs for his/her students as part of their knowledge construction process (Shear, Hafter et al., 2011; SRI International, 2012). The learning activity task can be as simple as the question that the teacher enquires at the beginning of a lesson within the student-centered pedagogy project-based activity, with the expectation that it can be extended beyond the classroom. Knowledge construction activity requires students to generate new ideas and understandings through interpretation, analysis, synthesis, or evaluation as part of the learning activity. The students need to apply and link the new knowledge information and ideas in a different context so as to deepen their understanding. Kidron and Monaghan (2009) stated that in order for the construction of new knowledge to take place, there is a need to design a suitable task, as part of the important stages in the process of abstraction, to connect the students' vagueness of its prior knowledge and realize the link to the new knowledge construction.

SRI International (2012) and Shear, Hafter et al. (2011) also defined knowledge construction as the natural ability skills of the students to reapply what they have learned into a new context. Knowledge construction took place when students were able to devise their own procedure processes through interpretation, analysis, synthesis, or evaluation. The ability of the students to link the newly constructed knowledge and go beyond knowledge reproduction of the acquired knowledge into the next new knowledge construction is when knowledge construction occurs.

Understanding how students construct using the Abstraction in Context (AiC) theory indicated that the process of new construct abstraction goes through three stages: the *need* for a new construct that abstract mathematical knowledge derives from the mathematical situations, the *emergence* of the new construct as the learner realises and makes sense of the new situations, and the *consolidation* of that construct to link the past knowledge with the future knowledge (Dreyfus, 2012). Furthermore, Hershkowitz et al. (2001) developed the methodological tool of the RBC-model to help analyse the emergence of new construct knowledge by describing students' processes of abstraction in a wide range of situations. The RBC-model, consisting of three observable theories, was based on the theory of knowledge AiC, where the R denotes *Recognising*, B denotes *Building with* and C denotes *Constructing*.

For a country's economy to develop, education plays an important role in providing programs that promote life-long learning and widening access to higher education. To make this into a reality, a teacher plays an important role in equipping our youth in the 21st century. Many studies on the quality and relevance of the teacher's classroom instruction practices in mathematics and language arts high school classroom in America, were conducted to investigate the relevance of the intellectual academic authenticity of the learning activity, with the development of the students' skills to construct knowledge (Matsumura et al., 2002; Mitchell et al., 2005). Teachers need to evolve in attitudes to use innovative teaching practices that promote student-centered pedagogy, and they need to adapt and re-adapt academic learning activity that may help students to develop critical thinking skills in analyzing, and use their reasoning ability skills to achieve better academic achievement.

The analysis results from the 26 item questionnaires carried out in Bahrain by Adolsary (2010) explored the classroom assessment practices of secondary school teachers, revealed a shocking discovery that most teachers still use traditional assessment tools to test and measure students' achievements. Both the teacher and the students are regarded as continuous learners. The teachers need to be more creative, innovative and have a sense of competition and persistence to be fully committed in designing a learning atmosphere that is conducive. Several studies proved the success of using project learning tasks and activities that promote students deeper understanding, sense of responsibility and boost their motivation as the students collaborated with their peers (Damit et al., 2015; Duraman et al., 2015; Sulaiman & Shahrill, 2015; Lim et al., 2016). Furthermore, there were observable evidences that mathematical conversations took place because the students were actively engaged in doing the designed learning activities (Darling-Hammond et al., 2008; Fazekas, 2011). According to Taale (2013), exposing the students through different teaching and learning pedagogy by using multiple representation instructions showed improvements in their academic performance and achievement in a Physics class.

Moreover, the teachers also need to have a sense of caring and empathy towards the needs of the students when using multiple representation instructions. This can indirectly boost self-confidence and motivation of the students to study. They need to have support not only from school but also from the Ministry of Education itself in order to make Brunei Vision 2035 (BEDB, 2016) into a reality. As mentioned by Koh et al. (2012), schools in Singapore need to equip and encourage teachers to adopt their own designed authentic assessment in teaching and learning not only to develop students' higher-order thinking skills but also in developing the 21st century skills. Therefore from all of the above studies, it can be observed that in order for an education system to go through educational transformation, educators are required to collaborate together to design various practical learning activities. The designed learning activity need to be coded so as to analyse the effectiveness in ensuring the students develop one of the important 21st century learning skills on knowledge construction. Brunei's education system remains a challenge for any teachers in using authentic assessment such as learning activity in order for knowledge construction to take place. In this study, an in depth research was designed to explore the effectiveness of teachers in designing and using the learning activity to construct Year 9 students knowledge in a mathematics class.

The Study

Mathematics is one of the core subjects offered in both Primary and Secondary educations in Brunei Darussalam, with the minimum teaching period of six period lessons per week. Each period lesson is about 30 minutes. The SPN21 mathematics curriculum is based on its pedagogical approach of 'Fun, Play and Learn More'. This approach gives the teachers autonomy to use diverse teaching methods and techniques in fully utilising the teaching aids to meet the students various learning styles, and stimulate the students' mind to think critically and creatively (Curriculum Development Department, 2011). In education, students are the main stakeholders in the schools. The teacher will act as a facilitator and counsellor that provide the students with the knowledge that incorporates a wide range of values and essential skills for the students' intellectual development and attitudes towards their learning.

Brunei Darussalam education system aims to be aligned with the Brunei 2035 vision. Brunei mathematics curriculum needs to be reformed in order to prepare the students with the wide range of possibilities of the 21st century needs and skills. In a study by Mundia (2010), he explored and discussed about SPN21 curriculum issues. And one of them was on the over-emphasis on examination results that affected the selection direction of individual life in terms of further studies, scholarships offers and employment opportunities. It is significant to have continuous reviews on the examinations for the socioeconomic development of the country.

The present study investigates the use of interdisciplinary learning activity to construct Year 9 students' knowledge in mathematics. The learning activity task design was interdisciplinary and unique as it combined more than one academic discipline such as Mathematics, English Language, Art, Geography and MIB (*Melayu Islam Beraja* in the Malay Language, and in the English Language Malay Islamic Monarchy). The study is important for several reasons. The first reason was to explore the effectiveness of the learning activity in helping Year 9 students to construct mathematical knowledge. Secondly it was to examine if the learning activity alone were sufficient for the Year 9 students to construct mathematical knowledge and control the teacher's conventional way of delivering a lesson in a classroom. The motives for such reform mentioned earlier were because of the low achievement of students and the consistent decrease in students' knowledge levels and skills. It was reported by Adolsary (2010) that students had the inability to apply what they learned in school into their daily life.

This study was guided by the following two research questions:

1. How did the learning activity assist students to construct mathematical knowledge?
2. To what extent did the learning activity assist students to construct mathematics knowledge and control teacher's conventional way of delivering a lesson in a classroom?

Methodology

Description of the Study

A quantitative method using pre-experimental design that focused on one group pre- and post-tests (Creswell, 2014), was used for this present study. The pre-test and post-test data were then analysed and the collected students' quantified document artefacts further supported the results. For this study, the pre-experimental design specifically on one-group pre-test post-test design was used to have a better understanding on the need for and impact of using designed learning activity to construct Year 9 students knowledge in mathematics. The participants were selected from a sample of 43 Year 9 students in one of the secondary schools in Brunei.

Data Collection Materials and Procedures

The research was conducted by collecting several quantitative data. The quantitative data used two instruments, the pre-test and the post-test (refer to Appendix 1) to answer the first research question. The interdisciplinary learning activity was then executed in between the two tests and these were conducted to measure the student's knowledge construction performance on the topic scale drawing. The analysed results from the pre-test and post-test were further supported from the quantified documents artefacts of 27 purposefully selected students' personal journals of the same sample of 13 formed group planners to answer the second research question.

The topic on scale drawing was chosen for this present study as it was stated in the Year 9 Brunei Darussalam general streaming mathematics syllabus D, which is a spiral continuation of the Year 7 mathematics course organization (Curriculum Development Department, 2011; Cambridge International Examination, 2013).

The pre-test was used to test the students' basic knowledge on scale drawing topic. The pre- and post-tests consisted of 11 similar items moderated with fellow colleagues, were taken from the student textbook and the Brunei-Cambridge GCE O Level past year examination questions. These items were piloted to selected samples of Year 9 students of different schools. The testing items consisted of four sub-topics from the Year 9 main scale-drawing topic.

- Item 1 was a question on basic ratios that involved sub-items on whole, decimal and fraction numbers problems.
- Item 2 focused on the conversion of ratio in the scale of 1 : *n* that involved sub-items of whole, decimal and fractions numbers.
- Items 3, 4 and 5 involved whole and decimal numbers on map conversion scale unit length word problems such as meter, centimeter and kilometer.
- For the last two items, 6 and 7, were questions on how to use the given scale, convert the unit of the length into drawing scale and draw the scale drawing by using geometry set tools.

The mark range for each item is from 2 to 4. However, 1 or 2 marks were given for providing the correct working to the problems, and 1 mark for writing down the correct answer at the answer space. For the scale drawing items, marks were allocated for conversion unit scale length, accuracy of drawing and completion of the scale drawing.

After the pre-test, the execution of the teacher's design project learning activity task instructions on scale drawing was given to the students (refer to Appendix 2). As previously mentioned, the learning activity task design was interdisciplinary combining more than one academic discipline in Mathematics, English Language, Art, Geography and MIB. In Mathematics, the learning goal was for the students to use suitable instruments to measure length, be able to convert real length in the form of 1 : *n* and use appropriate geometry tools to draw the assigned scale drawing problems. In English Language, the learning goal was for the students to write persuasively for their project report and personal journal, and do group presentation in front of their peers. In Art, the learning goal was for the students to use their creativity in visualizing the dream classroom arrangement. For Geography, the learning goal was for the students to apply their map reading skills between two allocated places. And in MIB, the learning goal was to incorporate the Islamic Bruneian values in their models.

The students were given a chance to form their own group. Each group consisted of 3 or 4 students with a total of 13 groups formed altogether. The project academic learning activity was used for the development of the student's knowledge construction. Professor Darling-Hammond and her colleagues (2008) who did a 50 years review stated that inquiry, design, and collaborative project approaches are effective for students gaining meaningful learning knowledge. There was evidence that the students gave their commitment in their studies and were actively involved by collaborating during the process of knowledge construction. The students were able to connect the classroom knowledge with the real world problems regardless of the family income and achievement levels background. Using the learning activity task had a significant impact on the student's academic achievement.

The authenticity of the learning activity task for this research was readapted from studies developed by Passalia and Server in high school Mathematics (Mueller, 2014). Thus, the reliability and validity of the re-adapted learning activity to local context was not an issue for this research. A checklist (refer to Appendix 3) from the Curriculum Development Department (2012) was used in evaluating the assessment task. The authenticity of the assessment tasks assigned to the students was analysed using the detailed set of definitions and rubrics developed by ITL Research (Shear, Hafter et al., 2011). For this present study, the learning activity task was given a code 5, the highest code in the knowledge construction skills development rubrics as it was moderated by panels of mathematics teachers and experts in mathematics education.

In the studies by Byrk et al. (2000), and Koh and Luke (2009), they analysed the characteristics of the learning activity by collecting the samples of student's academic assignments, together with teachers' written descriptive forms both conducted in the classes of two different countries, America and Singapore. The learning activity used consisted of a list of knowledge construction skills criteria that the students were expected to show and

were measurable. Glasson (2009) mentioned that the criteria used in designing the teaching and learning activity, not only provided the students with opportunities to understand the required criteria from the students to accomplish but also to develop the necessary 21st century skills. For this present study's learning activity task, two rubrics criteria (refer to Appendix 4) were developed for the students to assess the collaboration skills as a group and the flow of their oral presentations as a group in front of their peers.

To further support the pre-test and post-test results, group planners (refer to Appendix 5) and student's personal journal (refer to Appendix 6) were used to further support the analysed data collection results to answer the second research question. In an action research study carried out by Lim and Pugalee (2007) on communication and collaboration that focused on language and mathematics, they discovered that writing was a form of learning tools that allowed the students to be actively involved in knowledge construction by manipulating, integrating, restructuring and reflecting their own prior knowledge, belief and concept of a knowledge. For this present study, 27 students were purposely selected and analysed using the student's personal journal. Each student's journal was analysed according to the RBC-model, together with the assistance of the class subject teacher in order for each journal to be coded separately. The coded results of each journal from the class subject teacher were then compared with the researchers' coded results. Subsequently discussed and reached to an agreement with the suitable coding in RBC-model for each journal artefact. The class subject teachers act as moderators to support the reliability of the coded results.

The results from the analysis were then correlated to the students' academic achievements between the pre- and post-test results. Observation and measures of the pre- and the post-tests were descriptively analysed by using descriptive statistics of means, standard deviations and ranges; and paired sampled tests to compare the pre-test and post-test results after the execution of the designed learning activity. SPSS Statistics version 21 was used for the pre-test and post-test analysis.

Results

The selected 43 Year 9 students had an average age of 14 years old. Using descriptive statistics shown in Table 1, the pre-test had an overall mean of 4.35 with marks ranging from 0 to 12 out of total marks of 27, and a standard deviation of 3.32. The post-test had an overall mean of 10.35 with standard deviation of 4.35 ranged from 1 to 25 by using the same items as the in the pre-test.

Table 1. Descriptive statistics of pre-test and post-test results (n = 43)

	Range		Mean	Std. Deviation
	Minimum	Maximum		
Pre-test	0	12	4.35	3.32
Post-test	1	25	10.35	4.35

Referring to the paired samples test statistics between the post-test and pre-test (in Table 2), the significant 2-tails values of 0.000, where $p < 0.05$. This showed that the designed learning activity had a positive impact on the students' academic achievement as the mean difference between the post-test and pre-test was 6.

Table 2. Paired samples test statistics between post-test and pre-test

	Paired Differences		t	p
	Mean	Std. Deviation		
Post-test – Pre-test	6.00	4.15	9.49	0.000

In Table 3, the 11 pre-test and post-test items were used in testing the four sub-topics of the Year 9 main scale-drawing topic. Referring to the mean mark in both the pre-test and post-test results, application on scale drawing items ranked first; followed by items on conversion of scale 1 : *n* ranked second; the third ranked item was on basic ratio; and the last ranked item was on the word problem on map scale conversion items.

Out of the 43 students, only one student managed to get full marks out of 6, and 17 identified students managed to score more than 3 marks when compared to the pre-test maximum range marks. Whereas in the conversion of scale 1 : n items, six students managed to get full marks out of 6, and 11 identified students scored more than the maximum mark range in the pre-test results. Finally, three students obtained the full marks of 8 in the post-test application on scale drawing items.

Table 3. Descriptive statistics on 4 sub-topics of the year 9 main scale drawing topic (n = 43)

	Sub-topics	Range		Mean	Std. Deviation
		Minimum	Maximum		
Pre-test	Basic ratio	0	3	0.88	0.91
	Conversion of scale 1:*n*	0	4	1.09	1.15
	Word problem on map scale conversion	0	2	0.23	0.57
	Application on scale drawing	0	6	2.14	2.16
Post-test	Basic ratio	0	6	3.12	1.47
	Conversion of scale 1:*n*	0	6	3.23	1.77
	Word problem on map scale conversion	0	5	0.70	1.19
	Application on scale drawing	0	8	3.30	2.26

In the paired mean mark differences using paired samples test shown in Table 4, items on basic ratio and items on application on scale drawing had an opposite ranking when compared to the mean mark results ranking in Table 3. All the four sub-topics of the Year 9 main scale drawing topic from the post-test and pre-test were observed to have significant values of $p < 0.05$. These results showed that the learning activity had significant impact on all the four sub-topics in the pre-test and post-test result items.

Table 4. Paired samples test statistics on 4 sub-topics of the year 9 main scale drawing topic

Comparing Post-test and Pre-test	Paired Differences		t	p
	Mean	Std. Deviation		
Basic ratio	2.23	1.51	9.70	0.000
Conversion of scale 1:*n*	2.14	1.93	7.25	0.000
Word problem on map scale conversion	0.47	1.22	2.50	0.017
Application on scale drawing	1.16	2.36	3.23	0.002

The quantified artefact documents were also collected using the students' group planners and the student's personal journal. A total of 27 purposefully selected students' personal journal of the same samples from 13 formed group planners were used, coded and analysed to further support the pre-test and post-test results.

The learning activity task was designed in form of a story, and the students had to figure out what to do as a group to complete the task. The teacher monitored the progress of the students' group learning activity without much contribution on how to complete the task. In the 13 group planner artifacts, it was observed that the students were able to plan as a group (refer to Table 5). Furthermore, there were six identified main areas mentioned in their written group planner: 1) measuring the classroom floor space dimensions including doors and windows; 2) measuring the furniture dimensions (tables, chairs, white board, and posters); 3) planning for the furniture arrangement; 4) making a scale blue print (including labeling); 5) making a 3-dimension model; and 6) making brief explanation for presentation.

Table 5. Students' group planner evidence works on rearrange the class learning activity

Plan for	Percentage
Measuring the floor space dimensions including doors and windows	100
Making a scale blue print (including labeling)	100
Making brief explanation for presentation	100
Measuring the furniture dimensions (tables, chairs, white board, posters)	100
Making a 3-dimension model	76.9
Discussing/ Planning for the furniture arrangement	76.9

In the six identified group planner areas shown in Table 5, all the groups, with 100%, agreed on the importance to measure the classroom floor space dimensions including doors and windows; measure the furniture dimensions suitable for the classroom such as tables, chairs, white board and posters; make a scale blue print with labels; and a brief explanation for presentation. Meanwhile, 10 out of 13 groups (76.9%) decided to make a 3-dimension model; and planned for the furniture arrangement.

During the execution of the learning activity, individual students were asked to write down their own personal responses in the student's reflective journal tables provided (refer to Appendix 6) according to interest; value; importance; needed skills; needed resources; and needed time. Using the same sample of students from the pre-test or post-test, the 27 purposefully selected student's reflective journals were used. It was evident that the students wrote down their reflective journals based on the stages of the progress of their completion of learning

activity. The five identified stages began with planning stage; followed with the measuring stage; drawing the blue print stage; creating the model stage; and the last stage on group presentation.

Referring to Table 6 in analyzing using the RBC-model, in the planning stage of Recognizing (R) was observed in the student's journal. More than half of the 27 students, 55.6% wrote that they valued the importance of working together as a team. Less than 50% of the students wrote in their individual reflective journal that they expressed their interest to work as a team in contribution of ideas, discussion and planning, and the importance to prepare necessary resources for the completion of the learning activity task. This was evident from the student's journal where 51.9% of the students wrote the time duration range needed for the discussion and planning was from 15 minutes to 2 days.

Table 6. Student's personal journal in identified stages of learning activity

Stages	RBC-model			Written evidence	%
	Recognizing (R)	Building with (B)	Constructing (C)		
Planning				Value the importance of working together as a team.	55.6
	/			Importance to prepare necessary resources for the completion of the learning activity task.	51.9
				Express their interest to work as a team in contribution of ideas, discussion and planning.	40.7
Measuring				Essential skills such as measuring skills, estimating and converting units of length meter to centimeter.	88.9
		/	/	Resources needed: Measuring tape.	81.5
				Interested to measure all the dimensions of the classroom and know the importance of correct measurement.	33.3
				Calculator.	11.1
Drawing the blue print				Resources needed	85.2
		/	/	Mathematics skills in calculating the scale, designing and drawing skills with labels.	55.6
				Creativity in designing and drawing incorporating MIB concept.	48.2
Creating model	/	/		List out the resources and designing tools.	96.3
				Creativity skills.	88.9
Group presentation				Importance of each member of the group to do the presentation with their models.	40.7
		/	/	Skills needed to explain in English with clear voice and making eye contacts with their fellow classmates	40.7

Note: / indicates the existence of Recognizing (R), Building with (B) or Constructing (C).

In the measuring stage, according to the student's individual journal there were evidences of the Building with (B) and the Constructing (C). The needed time range for the measuring stage was from 30 minutes to 2 days. More than half of the 27 students wrote that they realized the essential skills needed for the learning activity task are measuring skills, estimating and converting units of length meter to centimeter; and also measuring tape was the needed resources for the measuring stage. Subsequently, 33.3% wrote that they were interested to measure all the dimensions of the classrooms and knew the importance of correct measurement; and only 11.1% wrote calculator as one of the needed resources for the measuring stage.

During the stage of drawing the blue print, both the B and the C were observed. According to the written journal, less than 50% of the students wrote that they were interested in the importance of using creativity to design, and drawing neatly the classroom arrangements with incorporation of the Brunei MIB concept. It was evident that more than half of the students wrote the skills needed for the blue print stage were the mathematics

skills in calculating the scale, designing and drawing skills with labels in the blue print; and listed out the resources needed for drawing the blue print. Only 18.5% of the students wrote the needed time range to list out the details of the blueprint and drawing the blue print was from 2 hours to 1 day. The blue print showed the designed scale-drawing plan of a classroom in representing the arrangement of the desired furniture.

For the creating model stage, both the R and the B were observed in the students' journals. The findings in Table 6 indicated that 96.3% listed out the needed resources and the designing tools in creating the model for the learning activity task. Whereas 88.9% of the students knew that creativity skills was a requirement in creating the model. The needed time range in creating the model stage was from 3 hours to 3 days as written by 33.3% of the students.

In the group presentation stage, a mixture of the B and the C was again observed. Based on the journal, only 11 students or 40.7% were interested in the importance of each member of the group conducting the presentation with their models. Similarly, 40.7% wrote that the needed skills for the presentation were to explain in English with a clear voice and to maintain eye contact with their fellow classmates. As for the needed time for the presentation, 51.9% of the students wrote that the sufficient time frame range was from 2 to 5 minutes.

Discussion

Responding to the first research question, a pre-test and post-test data analysis of the results was used. Before the execution of the teachers' designed learning activity task, a pre-test was given to the students with the hope that they could relate the pre-test with the teachers' designed task. It was observed that the students were able to perform best in application on scale drawing items as the students used their geometry set tools to solve the problems by drawing. The least attempted item on the pre-test was a word problem on map scale conversion. This indicated that the students were able to perform better on items that involved their visuals and hand movements to solve the problems, rather than trying to understand the question statements as in items involving word problems on map scale conversion.

There were improvements in the mean for all the four sub-topics of the Year 9 main scale drawing topic. The ranking positions of all the four sub-topics remained the same in the post-test when compared to the pre-test analysed results. Overall, the application on scale drawing items still had the highest mean score in both the pre- and post-tests. The lowest mean score for both the pre- and post-tests were on the word problem on map scale conversion items. There was a percentage increase of 0.47 between the post- and pre-tests. Hence, this result showed there was an improvement in the students' basic knowledge construction after the implementation of the teachers' designed learning activity task. The possible observable reason for such result was that during the execution of the learning activity task design, the students needed to use basic ratio for conversion of scales ratio and apply suitable scale in the stages of drawing the blue print and creating the model. Even though there was a slight increase in the mean marks for the word problem on map scale conversion, not much involvement in the word problem on scale conversion took place during the execution of the learning activity as was reflected in the post-test results.

According to statistical testing, the teacher's designed learning activity had an impact on the students' performance on all the four sub-topics of the Year 9 main scale-drawing topic. Indirectly through the designed learning activity, the students were able to learn all the related sub-topics unconsciously without the teacher directly teaching the lessons of those sub-topics. This was further proved using the paired samples test between the post-test and pre-test as it had a significant value of $p < 0.05$. Even though the mean difference was not that large, the significance value showed us that the learning activity in their post-test results did have an impact on the student's knowledge construction.

These showed the execution of the learning activity designed tasks had a positive impact on the students' ability to construct their own knowledge. This is aligned with the SPN21 Brunei education system's School Based Assessment for Learning (SBA*fL*) (Rashid & Jaidin, 2014). School Based Assessment (SBA) is part of the process involving a teacher's pedagogy and for the learning by students to take place inside a classroom (Botty & Shahrill, 2015; Damit et al., 2015; Yatab & Shahrill, 2014a, 2014b). The teacher as the facilitator creates a world of positivity and trust for the students to feel safe in the education environment (Shahrill, 20009; Shahrill & Clarke, 2014). Whereas Assessment for Learning (A*fL*) is a continuous formative assessment tasks accumulated from Year 7 to Year 8 of the lower secondary schooling in Brunei (Curriculum Development Department, 2011).

Moreover, the teacher created a task with specific criteria to promote teaching and learning with the belief that every student has equal opportunity not only to achieve better achievement academically, but also to prepare them for their own future with the essential practical skills in hand. Teachers have the autonomy to design their own informal assessment to better enhance the pace variety of the student's on-going learning processes in a classroom. Using SBA*fL*, both the teachers and the students can have a win-and-win situation where both can receive reliable and valid quality feedback using the rubric created (Curriculum Development Department, 2012). Students may also have a sense of responsibility in knowing where they are in their study, to reflect and self-assessed in order to know which direction they have to go to achieve their goals.

Answering the second research question, quantified document artefacts were used by using the group planners and the students' personal journals. Based on the study's findings, exposing the students to learning activity task in mathematics, they were able to be involved in constructing mathematics knowledge, as evidenced in their group planners, without the presence or assistance from their teacher. As shown from the group work conducted, the students knew the steps in completing the learning activity task. These were further proven in the 27 purposefully selected students' journals. The C from the RBC-model was observed in the student's journal in the measuring stage, the drawing stage and the group presentation stage. Thus, supporting the evidence that the learning activity assisted the students to construct mathematics knowledge even without the delivery of a normal teaching lesson.

Conclusion

Using several quantitative methods on pre-experimental designs focusing on one group pre-test and post-test design for 43 students of Year 9 general streaming mathematics Syllabus D topic on scale drawing, the analysed data showed an improvement in all the sub-topics items. The execution of the learning activity designed tasks indirectly helped the students to construct mathematical knowledge as reflected in the post-test analysed data.

This evidence was further supported from the coded and analyzed quantified documents artifacts of the same group planner students and 27 purposefully selected students. The students were able to collaborate on making decisions on what tasks need to be done as appeared in the designed story form learning activity. Looking into the individual student's journal evidence, further supported with the evidence from students group planners the learning activity alone was considered to be sufficient for the Year 9 students to construct mathematical knowledge without the teacher delivering the expected lessons on scale drawing topic. This piece of evidence as reflected in the students post-test results verified that students were able to construct knowledge independently as long as the learning activity designed were properly planned and designed.

Scope and Limitations of the Study

In this present study, the independent variable was the designed learning activity that could affect the dependent variable of Year 9 students to construct knowledge outcomes. The intervening or mediating variables between the independent and dependent variables were controlling the teacher's conventional in teaching the Year 9 scale and map problem topics. The whole processes from giving out the pre-test, carrying out the learning activity and giving out the post test took almost three weeks of mathematics lesson time table scheduled in the second school term. It took place during the correction weeks of the subject teachers' teaching schedule, which was after the Year 9 mid-year examination. The limitation of the research was the reliability of the analysed quantitative data might be an issue since the number of used samples was small. Due to time constraints the results did not reflect the whole Year 9 population in Brunei Darussalam since the study only involved one secondary school sample. The items used to test the students' achievement if possible to be included in the design learning activity task to measure the extent of learning activity in assisting the students to construct mathematical knowledge. Since this research was limited to only one Year 9 map and scale problems topic, the purpose in assisting students to construct mathematical knowledge might not be the same in other topics in mathematics.

Implications

This study may be taken as one of the few examples that the learning activity assisted the Year 9 students in constructing the relevant mathematical knowledge as observed in the post-test results and was further supported in the quantified documents collected from the purposefully selected students. By considering the effectiveness

of the learning activity, based on these evidences students' interest to learn mathematics have actually improved. These imply that a well-designed learning activity did help the teachers to promote the student-centered learning processes as required by the Brunei SPN21 education system. The results and findings from this study cannot be used to generalize other schools in Brunei. For future studies, it is recommended that the study to be conducted using all the topics to be taught in Year 9 throughout the whole year involving majority secondary schools in Brunei to investigate further the effectiveness of learning activity in assisting students to construct mathematical knowledge. An on-going professional development on authentic assessment for teachers' teaching and learning pedagogy are essential to promote knowledge constructions skills for the 21st century mathematics class.

Recommendations

Based on the findings from this present study, the following recommendations are proposed:

- Mathematics teachers should be encouraged and supported to design authentic and interdisciplinary learning activity that is learner centered to cater the different needs of the students to meet the 21st century skills demand.
- Fully monitored and ongoing training programs, seminars and workshops on authentic learning activity should be organized for mathematics teachers in secondary schools.
- Mathematics teachers should include innovation in their teaching integrating advancing technology to make learning more interesting to the learner in adopting the modern 21st century skills.

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Appendix 1. The Pre-test and Post-test

Answer **ALL** questions. Calculators are not allowed. Uses of Geometrical instrument sets are allowed.

1) Simplify the following ratios to their lowest terms.
(a) $58 : 696$ (b) $\frac{5}{6} : \frac{1}{3}$ (c) 40 cm to 1 m

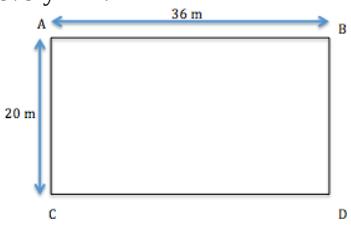
2) Express the following ratios in the form of 1 : *n*.
(a) $22 : 770$ (b) $8 : 0.64$ (c) $35 : \frac{5}{7}$

3) A map is drawn to a scale of 1 : 10 000. If two objects are 3 cm apart on the map, how far apart are they in real life? Give your answer in metre.

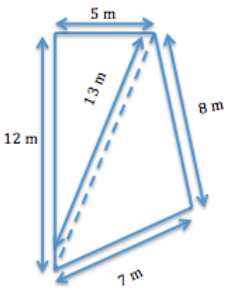
4) A model boat is drawn to a scale of 1 : 50. If the length of the real boat is 12 m, calculate the length of the model boat in cm.

5) A map is drawn to a scale of 1 : 50 000. If the real distance between house A and house B are 4.5 km apart, how far apart are they in map? Give your answer in cm.

6) A rectangular pool measures 20 m by 36 m as shown. Construct a scale drawing of the pool, using 1 cm for every 4 m.



7) A plan of a living room is shown below. Using a pair of compasses, construct a scale drawing of the room using 1 cm for every metre.



Appendix 2. Learning Activity Task

REARRANGE THE CLASS

The students will be able to
- ✓ Measure quantities using appropriate units, instruments and methods.
- ✓ Setup and solve proportions.
- ✓ Develop scale models.
- ✓ Estimate amounts and determine levels of accuracy needed.
- ✓ Organise materials.
- ✓ Explain their thought process.
- ✓ Demonstrate teamwork.

Task

You want to rearrange the furniture in your class, but your class teacher does not think it would be a good idea. To help persuade your class teacher to rearrange the furniture you are going to make a scale model of what the class would ultimately look like that incorporate the Brunei concepts of MIB.

You first need to measure the dimensions of the floor space in the room you want to rearrange, including the location and dimensions of all doors and windows. You also need to measure the amount of floor space occupied by each item of furniture in the room. These dimensions should all be stated clearly, in detail and listed. Then use the given proportion to find the scale dimensions of the room and all the items. Next you will make a scale blueprint of the room labeling where all windows and doors are on poster paper.

You will also make scale drawings of each piece of furniture on a cardboard sheet of paper, and these models need to be cut out. Then you will arrange the model furniture where you want it on your blueprint, and tape them down. You will finally write a brief explanation of why you believe the furniture should be arranged that way it is in your model.

Your models and explanations will be posted in the room and the class will vote on which setup is the best. You are expected to do a short presentation. The deadline for this competition is two weeks from today. You will work in groups of not more than 3 members so manage your time well.

Appendix 3. Curriculum Assessment Checklist

Checklist for evaluating assessment task (Curriculum Department and Development, 2012)

1	Does the assessment task assess the learning outcomes in the syllabus?	
2	Does the assessment task have clear and explicit assessment criteria that are aligned with the learning outcomes and made explicit to pupils and parents?	
3	Is the activity to be undertaken by the students clearly defined and the instructions clear?	
4	Does the activity have relevance or connection to the real world?	
5	Is the activity a worthwhile use of instructional time? - Does the activity align with and feed into other learning and teaching activities?	
6	Does the activity engage and motivate pupils to perform to the best of their ability?	
7	Is the activity one of many modes used to assess pupils' achievements to provide range and balance in assessment?	
8	Is the activity fair and free from bias? - Is the activity free from gender, racial, cultural, religious and socio-economic bias? - Do all pupils have equivalent resources – at home or at school – to complete the activity? - Do all pupils have equal opportunity to demonstrate their best? - Is the activity sufficiently flexible to allow different responses by different pupils?	

Appendix 4. Rubrics

Your grade will be based on the following criteria:

- Accuracy of calculations.
- Accuracy of measurements on the scale model.
- Floor plan is drawn neatly with all dimensions labeled.
- Pictures and prices included for furniture and decorations.
- Drawing of the room included, colored, and neat.
- Clear explanations.

Criteria	Unacceptable (0 point)	Poor (1 points)	Good (2 points)	Excellent (3 points)
Accuracy of calculations	No calculation	Calculated incorrectly	-	Calculated correctly
Accuracy of measurements on the scale model	Model has few or no measurements to scale	Model has some measurements to scale	Model has nearly all measurements to scale	Model has all measurements to scale
Floor plan	No floor plan included	Floor plan has some, but not all dimensions labeled	-	Floor plan has all dimensions labeled
Furniture and Decorations	Not included	Included with pictures but no prices	Included with pictures and prices	-
Drawing of Redecorated Room	Not included	Drawing is neat but not colourful or detailed	Drawing is neat, colourful, and detailed	-
Clear explanations	No explanation	Explanation with few or no details	Explanation with some details	Clear explain with many details

Total score: _____ / 20

Grading

A: 17 – 20 points B: 13 – 16 points C: 9 – 12 points D: 5 – 8 points F: 0 – 4 points

Criteria for Oral Presentation

- All members of the group are involved in the presentation.
- Eye contact is made with the audience.
- Knowledge is presented in a clear and concise fashion.
- Choice of methodology is given with explanation.
- Volume level is appropriate.
- Presentation stays within the time limits.

1 points	0 point	Weight
All members of the group are involved in the presentation	One or more group members do not participate in the presentation	× 2
Mathematical knowledge is presented in a clear and concise manner.	Mathematical knowledge is presented in a confusing or disorganized manner.	× 2
Presenters make eye contact with the audience throughout the presentation.	Presenters do not make or maintain eye contact with the audience.	
Presenters describe the groups' choice of methodology with an explanation for why they felt this was the best solution method to use.	Presenters describe the groups' choice of methodology, but do not explain why they felt this was the best solution method to use.	× 2
All class members are able to hear the presentation because appropriate volume is used.	Members of the class that sit in the back of the room have difficult time hearing the presentation.	
The presentation is of appropriate length.	The presentation is either too short or too long	

Total score: _____ / 9

Grading

A: 8 – 9 points B: 6 – 7 points C: 4 – 5 points D: 2 – 3 points F: 0 – 1 points

Appendix 5: Group Planner

Group Planner (Student Tool)

Plan for work on _____

Name or description of project or assignment goes here.

Name					

List group members' names

List each task to be done for the project.

Note each member's role and responsibilities for each task. Every box does not need to be filled.

Appendix 6. Student Reflective Journal

Reflective Journal: What does it mean to me? (Student Tool)

Assignment: _____

Name or description of assignment goes here.

Fill in the chart to help you see what this assignment means to you.

Interest	**Value**	**Importance**
Skills Needed	**Resources Needed**	**Time Needed**

Students reflect on their personal responses to the assignment.