STUDENTS' PERCEPTIONS ON SYNERGISTIC SCAFFOLDS FOR KNOWLEDGE INTEGRATION: OPPORTUNITIES, CONSTRAINTS AND IMPROVEMENT

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Abstract: Synergistic scaffolds are multiple forms of supports that interact with each other in a concerted way to facilitate a targeted goal. Synergistic scaffolds have been found to be effective to support student learning but there is little evidence to better understandstudents' perceptionsonhow synergistic scaffolds can help them integrate knowledge. This study exploredForm 1 students' perceptions on the challenges they faced and how synergistic scaffolds—question prompts and pre-planned scaffolding strategies—supported their knowledge integration processduring design activities. This study involved twenty-seven Form 1 students from a national school. Data was collected using a 4-point Likert Scale Questionnaire and student interviews. This studyshowed that the students faced challenges related to domain knowledge, language proficiency and task complexity. Question prompts, which were supported with active support by the facilitator, created an effective supporting system for knowledge integration. The facilitator adopted various scaffolding strategies to complement the question prompts. The students suggested that the synergistic scaffolds could be improved from the aspects of language, concept delivery and structure. The research findings provide guidance in pre-designing scaffoldings into instructional practice.

Keywords: *synergistic scaffolds, knowledge integration, students' perceptions, question prompts, scaffolding strategies*

INTRODUCTION

Knowledge integrationcan be defined asan "ability to generate scientifically normative ideas and use relevant theory or empirical evidence to connect ideas in explaining a scientific phenomenon or justifying a claim about a scientific problem" (Liu, Lee, & Linn, 2011)p. 116). Knowledge integration is a crucial element in transdisciplinary learning (Rafols & Meyer, 2010), which involves science, technology, engineering, arts and mathematics (STEAM). During the process of knowledge integration, students elicit ideas to acknowledge their knowledge gaps, add on ideas to existing knowledge, distinguish ideas to identify the most appropriate solutions based on nuanced criteria and seek evidences to support valid connections between ideas (Chiu & Linn, 2011; Davis & Linn, 2000). However, students always visualise each subject distinctively even though there are congruent fundamental concepts across these subjects(Cheville, McGovern, & Bull, 2005). They seldom make meaningful connections between similar tasks in different contexts (Liu, Lee, Hofstetter, & Linn, 2008). In response to these challenges, scaffolding needs to be provided to students to help them integrate knowledge (e.g., (Bell, Davis, & Linn, 1995; Davis & Linn, 2000).

Scaffolding refers to temporary support given to learners when they learn to gain conceptual understanding and skills to progressively move towards independent learning (Maybin, Mercer, & Stierer, 1992). Scaffolding helps learners develop the abilities to provide explanations for core concepts underlying a design solution (Baumgartner & Reiser, 1998). Students need scaffolding to reflect and reorganise the connections between their ideas to form a more coherent and integrated understanding of a task(Davis & Linn, 2000). Davis and Linn (2000) stressed that planning appropriate types and frequency of scaffolds can make the connections between learning steps and linkages between scientific knowledge explicit to students to avoid development of fragmented ideas. Scaffoldinghelps students create conceptual frames and use evidences in explanations, create good criteria as well as build scientifically normative arguments(Bell et al., 1995).

In a complex transdisciplinary learning environment, scaffolding needs to be distributed among multiple tools and agents to support students with different learning needs (Kim, 2017). Synergistic scaffolds are multiple forms of supports that interact with each other in a concert way to facilitate a targeted goal (Tabak, 2004). Synergistic scaffolds are "enmeshed, intertwined and complete each other" (Tabak, 2004, p. 319). Synergy can occur between fixed and adaptive scaffolds over a sequence of learning activities (Tabak, 2004). Fixed scaffolds are static supports which are planned in advance to the implementation of lessons (Azevedo, Cromley, Winters, Moos, & Greene, 2005; Saye & Brush, 2002) while adaptive scaffolds are responsive, dynamic and situational scaffolds provided to students based on their emerging performances (Azevedo et al., 2005; Saye & Brush, 2002).

Past studies on scaffolding have been limited to the type and effect of scaffoldingon student learning (e.g., (Bell et al., 1995; Davis & Linn, 2000; Li & Lim, 2008; Linn, 2000). The effectiveness of scaffolding iseither evaluated through quasi-experimental study (e.g.,(Ge, Planas, & Er, 2010; Linn, 2000; McNeill, 2006)or students' performances in pre- and post-test (e.g.,(Kim, 2017; Li & Lim, 2008).Study on students' perceptions on the synergy between different forms of scaffolds is scarce. In fact, the students are in the best position to assess the adequacy of synergistic scaffolds and provide suggestions for improvement as they are the main stakeholders in an intervention. With sufficient knowledge on students' standpoints, it would be easier for facilitatorsto design instructional materials that could effectively and efficiently support students' learning needs(Talley, 2014). Therefore, the aim of this study was to investigate the opportunities, constraints and methods of improving synergistic scaffolds—question prompts and facilitator's scaffolding strategies—for knowledge integration from students' perspectives. The question prompts in this study referred to a set of questions which prompted students to integrate knowledge. The facilitator's scaffolding strategies referred to the structure, techniques and procedures that the facilitator used to help students connect concepts from the STEAM subjects when they constructed an artefact.

METHODOLOGY

Research Context

The students were required to use knowledge from the STEAM subjects to design, construct and test a water filter which could provide clean water to villagers inhabiting remote areas. This real-life issue involved various concepts from the STEAM subjects, as shown in Table 1.

Table 1
Examples of Concepts from STEAM Subjects

Subjects	Examples of concepts
Science	Filtration (concept, advantages, disadvantages), Separation methods, Physical Quantities (length, mass, time, volume)
Design and Technology	Engineering design process, Management of project
Arts	
• Visual Art	Art elements (e.g., colours, patterns, lines, harmony)
• Geography	Water resource, Water crisis issues (causes, effects)
Mathematics	Basic arithmetic operations, Basic measurement (length, mass, time, volume), Speed

Some prompt samples which helped the studentsdesign their water filterare shown in Table 2. For example, the prompts helped the students use their prior knowledge to describe the causes of the clean water issue. The prompts also guided the students to evaluate their design solution based on the design criteria. The facilitator moved from group to group to provide calibrated supports based on the students' emerging learning needs. The facilitator drafted a list of generic and specific prompting questions to complement the question prompts. Examples of generic question prompts include 'What do you understand about this issue?', 'Do you have enough information to solve this problem?'. Specific question prompts include 'What are the different ways of arranging the filtering materials?', 'Why do you integrate this art element?'.

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Table 2
Sample Question Prompts from SSKI-DBL Module

Activities	Question prompts
• Identifying learning issue	IL.Q1. Explain the problem faced by the villagers in the remote areas of Malaysia? • What is the problem? • What causes contribute to this problem? *Hints: Use general knowledge or knowledge from other subjects such as Geography to answer this question.*
• Evaluating strengths	ES.Q6.What are the strengths of your water filter? • Can the water filter solve the clean water shortage issue? • Which design criteria does it fulfil?

Participants

The participants consisted of twenty-seven Form 1 students from a multi-ethnicsuburban secondary school. Fourteen students were male. The studentbackground information is shown in Table 3.

Table 3
StudentBackground Information

	Gender (Total frequency)		
Race	Male	Female	Total
Malay	7	8	15
Chinese	5	2	7
Indian	2	2	4
Kadazan	0	1	1
Total	14	13	27

Methods

This study was conducted using a two-cycle design-based research (DBR) approach. DBR is an iterative process of designing, developing, implementing, evaluating, refining and reflecting (Design-Based Research Collective, 2003). This study was the first of the iterative cycles of design and implementation to collect data to improvise the design of synergistic scaffolds in the subsequent cycle.

The data was collected from Synergistic Scaffolds Questionnaire (SSQ) and studentinterviews.The questionnaire was developed from the existing literature on supporting studentlearning when they involved in design activities (e.g., (Baumgartner & Reiser, 1998; Davis & Linn, 2000; Hmelo, Holton, & Kolodner, 2000; Linn, 2000; Puntambekar & Kolodner, 2005). The SSQ consisted of sixclosed-ended questions (derived from a longer survey instrument) related to the students' perception on the challenges they faced and supports provided by synergistic scaffolds to help them integrate knowledge. Each question consisted of a number of items. The students' responses to the items were coded on a 4-scale Likert scale: 1 (SD: Strongly Disagree), 2 (DA: Disagree), 3 (A: Agree) and 4 (SA: Strongly Agree).The students answered the SSQ in 30 minutes at the end of the 18-hour module. The questionnaire was pilot testedwith 15 students and was computed using the SPSS 17.0 package. The Cronbach's alpha coefficient of the pilot test was 0.747.

One day after the students completed the questionnaire, the students were interviewed in groups to unravel more insights on (a) the challenges facing the students when they learned to integrate knowledge, (b) the wayquestion prompts and facilitator's scaffolding strategies helped them integrate knowledge; and (c)the suggestions to refine the synergistic scaffolds. The interview questions were also pilot-tested with a student to make sure that the questions were comprehensible and could address the research questions.

The data from SSQ was analysed using descriptive statistic. Each item in the SSQ was complemented with the excerpts obtained from the interviews. The excerpts were used as examples and elaborativesupports for the items in the questionnaire. The student interviews weretranscribed verbatim, coded and categorised into themes to understand the opportunities, constraints and suggestions for improving the design of the synergistic scaffolds.

RESULTS AND DISCUSSIONS

The result findings showed that the students agreed that synergistic scaffolds could support their STEAM knowledge integrationduring design activities. The students' perceptions on the constraints, opportunities and refinement methods of the synergistic scaffolds are discussed in the following section.

Question 1: What changes did you face during knowledge integration?

The data for the challenges facing the students when they learned to integrate knowledge is shown in Table 4.

Table 4
Challenges in Knowledge Integration

Codes	Statements	SA=4 (f, %)	A=3 (f, %)	DA=2 (f, %)	SD=1 (f, %)	Mean
101	Cannot understand the concept of STEAM	5 (18.5)	8 (29.6)	9 (33.3)	5 (18.5)	2.48
102	Lack of knowledge in STEAM subjects	4 (14.8)	6 (22.2)	15 (55.6)	2 (7.4)	2.44
103	Unable to link concepts from STEAM subjects	0	3 (11.1)	20 (74.1)	4 (14.8)	1.96
104	Cannot understand the design tasks	0	1 (3.7)	21 (77.8)	5 (18.5)	1.85
105	Cannot give detailed explanation because of language problem	2 (7.4)	2 (7.4)	22 (81.5)	1 (3.7)	2.19
106	Cannot collaborate with group members	1 (3.7)	3 (11.1)	12 (44.4)	11 (40.7)	1.78
107	Group discussion is monopolised by one member	2 (7.4)	3 (11.1)	16 (59.3)	6 (22.2)	2.04
108	Cannot communicate with facilitator	1 (3.7)	0	12 (44.4)	14 (51.9)	1.56
109	Insufficient time to complete tasks	0	11 (40.7)	12 (44.4)	4 (14.8)	2.26

Overall, the students did not think that they encountered a lot of challenges during the process of knowledge integration. The mean score for all challenges ranged between 1.50 to 2.50. The biggest challenges they faced were related to domain knowledge. About 40% of the students lacked an understanding on the concept of STEAM (statement 101) and content knowledge of the STEAM subjects (statement 102). For instance, two students explained,

> *Some concepts are newlike design process and STEAM concept.* (S15.L23.27717)
> *This was the first time I learned a concept through design activities. I built a moving car during Design and Technology in standard six. But I built it according to the steps and instructions.* (S18.L54.27717)

Approximately 90% of the students could understand the design problem (statement 104) and integrate knowledge from the STEAM subjects to solve the problem (statement 103). This finding was inconsistent with the previous studies which showed that students were less able to link concepts across different subjects(Cheville et al., 2005; Chiu & Linn, 2011). It was possible that the students in the current research had prior knowledge about the concepts underlying the design task such as filtration, filtration rate and arts elements.

More than 80% of the students agreed that they did not face language problem(statement105). However, the students' interviews revealed that the non-native Malay language speakers thought that their low proficiency in Malay language hindered their learning in three ways: (a) less communication with their peers with different native language; (b) inability to articulate their ideas effectively; and (c) inability to understand the vocabulary used in the question prompts. For example, the non-native Malay language speakers explained,

> *I faced language problem…sometimes, I cannot communicate effectively with Elagovan. (with different native language). I could not share a lot of ideas with him* (S14.L14.27717)

> *I could not understand the meaning of some terms in the prompts. I had to ask for help from facilitator or my group members.* (S16.L15.27717)

Less than 20% of the students thought that they had communication issue with their group members (statement 106) and the facilitator (statement 108). The students could share and negotiate ideas with their peers (statement 107) but they found it hard to achieve consensus among themselves,

> *It was hard to distribute the jobs among ourselves. Some members might not like it. Mostly, we did all jobs together.* (S12.L52.26717)

> *We all have our own ideas and opinions. It is hard to decide which idea is better or join our ideas. We took a long time to discuss but the time was not enough.* (S20.L12.27717)

About 40% of the students agreed that time constraint affected their knowledge integration process (statement 109). For example, two students said,

> *We were running out of time. We did not have enough time to think deeply about a question. So, we did not elaborate our answers.* (S2.L17.26717)

> *One hour was not enough for us to understand and use all concepts to explain our design. If we spent a lot of time on designing the filter, then we did not have time to build it.* (S10.L26.26717)

Question 2: Did you need both question prompts and facilitator's scaffolds (supports)toovercome the challenges in knowledge integration?

The students' perception on the role of synergistic scaffolds in supporting their knowledge integration is shown in Table 5.

Table 5
Students' perceptions on synergistic scaffolds for knowledge integration

Codes	Statements	SA (f, %)	A (f, %)	DA (f, %)	SD (f, %)	Mean
301	Question prompts and facilitator's supports helped me integrate knowledge	20 (74.1)	7 (25.9)	0	0	3.74

All students agreed that question prompts and facilitator's scaffolding strategies worked in concert to support their learning. For example, they said,

> *Prompts could help us (connect concepts) but sometimes I still faced some language problems. The facilitator explained, gave examples and translated the prompts. She reminded us to be creative and use our skills to design.* (S14.L9.27717)

> *Without thefacilitator's help, maybe we could not understand and answer some of the prompts. She understood our needs, so (she) could give instant help.* (S23.L38.27717)

> *We could answer (the prompts) better when the facilitator was present, especially when she was 100% with us. It is important to have her with us so she could give support on the spot.* (S27.L26.27717)

This finding was consistent with the previous studies which showed that question prompts alone was still far from a perfect instructional means to support students learning (e.g., (McNeill, 2006; Tabak, 2004).The reason was students might not have sufficient prior knowledge or experience in using fixed scaffolds (Belland, Glazewski, & Richardson, 2008). Unclear instructions also cause students to misinterpret fixed scaffolds and unaware of the actual function of these scaffolds (Belland et al., 2008).

Question 3: How didthe question prompts help you integrate knowledge?

The students' opinions on the support provided by the question prompts are shown in Table 6.

Table 6
Students' Perceptions on Question Prompts

Codes	Statements	SA (f, %)	A (f, %)	DA (f, %)	SD (f, %)	Mean
301	Focus attention on the main question	9 (33.3)	13 (48.1)	5 (18.6)	0	3.15
302	Provide hints on specific knowledge	9 (33.3)	15 (55.6)	3 (11.1)	0	3.22
303	Remind us to think from multiple perspectives	9 (33.3)	16 (59.3)	2 (7.4)	0	3.33
304	Trigger thinking	8 (29.6)	15 (55.6)	4 (14.8)	0	3.15

Overall the students agreed that the question prompts could help them integrate knowledge as they were reminded to consider their solution from different perspectives (statement 303) and use content knowledge from the STEAM subjects to solve the design task (statement 302). The students explicated,

> *The prompts gave us reference. They are like the examples. They helped us see a question from different angles.* (S7.L35.26717)

> *The prompts helped us identify the concepts from STEAM which could be used to answer the questions. The prompts further explained and elaborated the questions.* (S24.L20.27717)

Besides, the prompts helped the students stay focused on the requirement of the question (code 301) and triggered their ideas to solve the design task (statement 304).

> *"The prompts made it easy to answer the questions. The prompts gave us hints and helped us focus on the main questions. Without the prompts, we might have no idea on how to answer the questions.* (S19.L20.27717)

These findings were in agreement with the previous research which found that question processes such as developing content knowledge, elaborating ideas, justifying solutions and making inferences (Ge et al., 2010). Question prompts have also been proven to be beneficial in developing students' metacognitive skills particularly self-regulatory, evaluation and reflection(Davis & Linn, 2000; Ge et al., 2010). Past studies have shown that question prompting is an effective instructional strategy to induce productive cognitive(Ge et al., 2010).

Question 4: How did the facilitatorcomplement the question prompts to help you integrate knowledge?

As shown in Table 7, the students strongly agreed that the facilitator deployed various types of scaffolding strategies to augment the affordances and constraints of the question prompts.

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Table 7
Students' Perceptions on Facilitator's Scaffolding Strategies

Codes	Statements	SA (f, %)	A (f, %)	DA (f, %)	SD (f, %)	Mean
401	Used simpler and comprehensible terms	20 (74.1)	5 (18.5)	1 (3.7)	1 (3.7)	3.63
402	Gave examples/ modeling	22 (81.4)	5 (18.6)	0	0	3.82
403	Asked question (to trigger thinking/ reflect on design solution)	17 (63.0)	10 (37.0)	0	0	3.63
404	Summarized and made conclusion	13 (48.1)	14 (51.9)	0	0	3.48
405	Clarified misunderstanding/ misinterpretation of prompts	15 (55.6)	9 (33.3)	1 (3.7)	2 (7.4)	3.33
406	Provided suggestions/ feedbacks	14 (51.9)	13 (48.1)	0	0	3.52
407	Emphasised the need to use concepts from STEAM concepts	12 (44.4)	14 (51.9)	1 (3.7)	0	3.41
408	Linked to prior knowledge	20 (74.1)	4 (14.8)	3 (11.1)	0	3.63

All students agreed that the facilitator asked questions (statement 403) to guide them to answer the question prompts.

> *The facilitator asked many questions to trigger our ideas. I learn how to think and answer a question better.* (S18.L33)

> *When the facilitator asked questions, I started to think. Sometimes my answers were incomplete, when she asked more questions, I could add more detailed explanations.* (S24.L45)

The students strongly agreed that the facilitator gave a lot of examples and modeled the methods to integrate knowledge (statement 402).

> *The facilitator explained the questions and prompts. Then, she gave exampleslike how we could compare the first and second filter. She showed us how to compare the filtering time between the two filters.*(S8.L35)

> *I had more confidence to answer the questions after the facilitator showed us examples. I could provide an explanation mimic hers.* (S20.L28)

Approximately 90% of the students thought that the facilitator paraphrased the prompts (statement 401) to help them understand the question prompts. For example, they explained,

> *The facilitator used simpler language to explain the prompts. She replaced the difficult words in the prompts with simpler words.* (S6.L33)

> *The facilitator explained the prompts with simpler language and more elaborations. Her explanation was more suitable with our standard.* (S14.L29)

Similarly, about 88% of the students agreed that linking the new design task to their prior knowledge could help them integrate knowledge (statement 408). This strategy can also reduce students' cognitive load as they have stored relevant information in their working memory(Kirschner, Sweller, & Clark, 2006). The students explained,

> *At first, it was hard for me to understand how to link the concepts from different STEAM subjects. After the facilitator asked us to name some concepts from science, mathematics, design and technology class, I knew that those concepts could be linked.* (S27.L3.27717)

When the facilitator made us see that we could use our existing knowledge from science, arts and mathematics to design a filter, we felt more confident to complete the job. We could better understand how to use different knowledge to design the filter. (S15.L21.27717)

The facilitator also provided feedbacks to help the students improve their responses to the prompts (Line 406). The students explained that,

The facilitator pointed out our weaknesses so we can add in more explanations to improve our answers. (S9.L68.26717)

The facilitator checked our answers and told us our mistakes or what is not good about our answers. For example, when we only explained about the filtering time, she commented that we should explain from other aspects.(S26.L66.27717)

The facilitator's feedback helped the students notice the weaknesses of their responses to the prompts and take action for future improvement (Hmelo et al., 2000). It was also found that the facilitator summarised the content of the whole class discussion (statement 404), clarified the students' misunderstandings and constantly reminded them to link the concepts from the STEAM subjects (statement 407) when they solved the design task (statement 405). The students depicted that the facilitator used figures to summarise crucial features of knowledge integration:

The facilitator drew pictures to summarize ideas and helped us see the relationships between ideas, So, the difficult links became easier to understand." (S4.L28.26717)

It is difficult for us to understand the links between different concepts by listening to the long explanation. When the facilitator used diagrams and PPT slides, the relationships between different factors became clearer.(S19.L37.27717)

Question 5: Which aspects of the question prompts need to be refined to better support knowledge integration?

The students' suggestions on the ways to refine and redesign the question prompts are shown in Table 8.

Table 8
Students' Suggestions on RefiningQuestion Prompts

Codes	Statements	SA (f, %)	A (f, %)	DA (f, %)	SD (f, %)	Mean
501	Using simpler language	14 (51.9)	10 (37.0)	3 (11.1)	0	3.33
502	Number of prompts (either add or remove)	0	4 (14.8)	17 (63.0)	6 (22.2)	1.93
503	Difficulty level (i.e. compatible with students' ability)	12 (44.4)	11 (40.7)	1 (3.7)	3 (11.1)	3.19
504	Presentation of prompts (e.g., use tables)	14 (51.9)	11 (40.7)	2 (7.4)	0	3.44

About 90% of the students thought that (1) simpler language should be used in the prompts (statement 501), (2) the prompts needed to be simplified (statement503), and (3) presentation of prompts in a table avoid confusion (statement 504).

Prepare bilingual promptsora vocabulary list. (S14.L32.27717)
Shorten the prompts and use simpler language. (S15.L26.27717)

The students who suggested to present prompts in tables said,

We could fill in the table with our ideas easily. The prompts in the table are short and easily understood. (S13.L19.26717)

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A table is easy to use. One column for improving the cost. One column for improving the attractiveness. Then we added in more information.
(S19.L34.27717)

The prompts presented in theform of tables (1) helped the students organize ideas, (2)reduced their cognitive load and (c) focused their attention on important ideas to avoid oversight of key information which needed to be collected and analysed (Stuyf, 2002). In addition, excessive prompts might not bring a sense of accomplishment to the students due to high cognitive demand(Chen & Bradshaw, 2007). The students thought the number of prompts was sufficient (statement502):

The prompts helped us focus on the main idea. We do not need a lot of prompts. Prompts which do not help us to answer the questions make us confused. (S3.L27.26717)

The number (of prompts) is sufficient as the prompts are related to STEAM concepts. Therefore, when we answer the prompts, automatically we apply STEAM knowledge. (S20.L24.27717)

Question 6: How can the facilitator better complement the question prompts?

Table 9 shows the students' perceptions on the refinement of facilitator's scaffolding strategies.

Table 9
Students' Suggestions on RefiningFacilitator's Scaffolding Strategies

Codes	Statements	SA (f, %)	A (f, %)	DA (f, %)	SD (f, %)	Mean
601	Provide small group scaffolding more frequently	16 (59.3)	9 (33.3)	2 (7.4)	0	3.59
602	Provide motivation	11 (40.7)	10 (37.0)	3 (11.1)	3 (11.1)	3.07
603	Integrate ICT (e.g., animation, video)	16 (59.3)	9 (33.3)	2 (7.4)	0	3.60
604	Provide more chances for students to articulate ideas during whole class discussion	1 (3.7)	2 (7.4)	15 (55.6)	9 (33.3)	2.81
605	Encourage cross-group interaction	10 (37.0)	12 (44.4)	5 (18.6)	0	3.19
606	Set class/ group rules to make sure every student contribute to group works	1 (3.7)	4 (14.8)	18 (66.6)	4 (14.8)	2.07

More than 90%of the students agreed that small group scaffolding was effective as the facilitator could explicitly address the students' learning needs (statement601). A similar number of students welcomed the integration of information, communication and technology (ICT) (statement 603) into the knowledge integration process. The students explained that,

Facilitators can use PowerPoint presentation, videos or animations more frequently. Animations are interesting. We can understand a concept such as how filtration happens easily.(S8.L76.26717)
Facilitators can prepare some PowerPoint slides. If we miss her verbal explanation, we can still refer to the slides. (S1.L34.26717)

Besides, 80% of the students agreed that the facilitator should encourage the students to interact with their peers from other groups to promote exchange of ideas (statement 605). For example, two students said,

When we listen to our friends' ideas, we can compare my group design with theirs. It willmake usrethink about our design so that we can improve our design. (S27.L39.27717)

I took a look at how my friends from other groups design their solution. I also asked them the meaning of some terms. The facilitator never told us whether we could discuss with our friends from other groups. (S11.L43.26717)

About 78% of the students agreed that they needed motivational support from the facilitator (statement602). On the other hand, about 85% of the students thought that they already had enough chances to articulate ideas (statement 604). Only about 18% of them thought that it was necessary to set class or group rules to ensure active participation from all students (statement 606). This finding contradicted with the previous study which showed that highlighting group rules was essential so that students could take on more responsibility on their learning through collaboration and cooperation(Baxter & Williams, 2010).

CONCLUSION

Even thoughknowledge integrationin transdisciplinary learning has received considerable attention in education research, supporting students' knowledge integration with synergistic scaffolds requires more research as challenges increase when multiple supports are involved. The present study explored the challenges facing students during knowledge integration process and how these synergistic scaffolds could help students integrate knowledge from their perspectives. This study can help researchersand educators gain insights on ways to refine synergistic scaffolds to better support knowledge integration. Consistent with previous studies(e.g. Cheville et al., 2005), the students thought that they were less able to see the connections between various concepts and lacking of content knowledge to solve the task. Language proficiency issue hampered the students from understanding the question prompts and articulating their ideas. Bilingual students inethnically and linguistically diverse classroomsstruggle in such settings as they struggle to build on the foundations of their second language(Bakker & Smit, 2017). The issue of developing contextually related words is caused by students' culture and daily experiences (Campbell, Adams, & Davis, 2007). However,scaffolds are not quick fix options for enhancing student' language proficiency (Talley, 2014).Facilitators need to provide more opportunities for students to communicate and articulate their ideas using formal language (Talley, 2014).

The research findings found that the question prompts fulfilled different scaffolding functions to help the students integrate knowledge. The question prompts directed the students to important aspects of knowledge integration, guided them for explanation as well as facilitated their self-reflection in redesigning the solution (Davis & Linn, 2000; Ge et al., 2010; Puntambekar & Kolodner, 2005). However, thequestion prompts alone was still far from a perfect instructional mean to support the students' advanced knowledge(e.g., (McNeill, 2006; Tabak, 2004). The students thought that effective synergistic scaffolding required Facilitators' scaffolds which worked in concert with the question prompts (e.g., (McNeill, 2006; Tabak, 2004; Ustunel & Tokel, 2018).Facilitatorscan make the affordances of question prompts more explicit to students by providing clear instructions to use this type of scaffold (Belland et al., 2008). Furthermore, thestudents' performance in knowledge integration was not the result of one particularscaffoldingstrategy that the facilitators used,but a combination of different strategies which worked as a system (McNeill, 2006; Ustunel & Tokel, 2018). For example, the facilitator paraphrased the question prompts to help the students with unsatisfactory language proficiency to understand the prompts. The facilitator also asked questions, highlighted crucial features of knowledge integration and provided feedback to help the students improve their design solution.Facilitators' instructions, suggestions and constant discussions could clarify students' ideas and help them identify learning issues (Puntambekar & Kolodner, 2005).

As the stakeholders, the students provided various recommendation to improve the design of synergistic scaffolds. It was found that the question prompts needed refinement from the aspect of language, difficulty level and presentation of prompts. In addition, facilitatorscould provide small group scaffolding more frequently besides whole class scaffolding. As suggested in previous research, cross group interaction which happen naturally could encourage idea-sharing (Hmelo et al., 2000). In addition, integration of ICTcould enhance the effectiveness of scaffolding as students can visualise the problem and use the videos, graphs or animations as a point of reference(Barron et al., 1998; Li & Lim, 2008).

This study can help researchers and teachers understand how synergistic scaffolds support students' knowledge integration from students' perspectives. This study can provide guidance on teacher professional development as itprovidesteachers with guidelines in shaping their new roles in scaffoldings. Teachers should work in concert with fixed scaffolds, while still recognising and promoting students' rolesin learning as the ultimate goal of scaffolding is to transfer the learning responsibility to learners. Teachers need to have a better understanding on how to distribute scaffolding tasks to multiple tools and agents in a classroom with multiple ZPD so that each individual could be guided to achieve his/ her full competence. They also need to have positive views on the legitimation and crucial roles of synergistic scaffolds (Saye & Brush, 2002; Van de Pol, 2012). They must be willing to invest time to design fixed scaffolds and calibrating their practices based on students' learning needs. Teachers need to be equipped with pedagogicalcontent knowledge and mental agility (Maybin et al., 1992; Van de Pol, 2012) to be able to provide more active support in envisioning synergistic scaffolds.

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