Embedding *I-think* Tools in an ITVC Chemistry Virtual Classroom: A Study Among High and Low Spatial Ability Students

Penerapan alat pembelajaran i-think dalam Kelas Maya Kimia ITVC: Satu Kajian dalam Kalangan Murid Keupayaan Spatial Tinggi dan Rendah

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ABSTRACT

The purpose of the study was to develop and investigate the effect of *i-think* embedded virtual chemistry classroom (ITVC) on students' higher order thinking skills (HOTS). This study also differentiates the effect of ITVC on interest among students with high and low spatial ability. The development phase involved the use of ADDIE Model in designing ITVC and conventional virtual chemistry classroom (CVC). The effectiveness investigation phase used a quasi experimental design involving 66 forms four students in a secondary school in Kuantan. 33 students (control group) learnt via CVC while another 33 students (treatment group) learnt via ITVC. Both ITVC and CVC were developed using the Google Classroom application provided by Malaysia Ministry of Education. ITVC was enriched with the *i-think* thinking tools while the comparison table was used in CVC. Four research instruments used were electrochemistry HOTS achievement pre-test, electrochemistry HOTS achievement post-test, spatial ability test and interest questionnaires. Data collected were analysed using t-test to answer the research questions. Results show higher electrochemistry HOTS achievement for low spatial ability (LSA) and high spatial ability (HSA) students in post-test compared to pre-test in both groups. LSA in the treatment group shows higher electrochemistry HOTS achievement compared to the control group. ITVC also caused electrochemistry HOTS achievement for LSA in the treatment groups to be equal to HSA in the control group. The interest results indicated that LSA in both, control and treatment groups have high interest in electrochemistry. The findings revealed that embedding *i-think* learning tools in the virtual classroom could act effectively in enhancing HOTS and interest among chemistry students. ITVC also enabled teachers to apply 21st century learning among students towards the realization of 4.0 Industrial Revolution (IR4.0).

Keywords virtual classroom, *i-think* learning tool, spatial ability, higher order thinking skills, interest, electrochemistry

INTRODUCTION

Higher Order Thinking Skills (HOTS) are cognitive skills that involve students applying, analyzing, evaluating and creating in their thinking processes [1]. Many research studies have reported that HOTS among teachers and students are very low [2]. To overcome this situation, Ministry of Education (MOE) collaborated with Innovation Malaysian Agency (IMA) to create eight types of *i-think* thinking maps, which were circle, bubble, double-bubble, tree, brace, flow, multi-flow and bridge to enhance HOTS among students. *I-think* thinking maps act as one way to help students structure their own thinking process [3].

The *I-think* thinking circle map was used for defining in context, bubble map for describing fact, double bubble map for comparing and contrasting, tree map for classifying, brace map for explaining part-whole relationship, flow map for structure a sequencing fact, multi-flow map to explain cause and effect and bridge map for seeing analogies [1]. Moreover *i-think* thinking maps promotes the thinking process among students [4]. The thinking map also helps students visualize better and decrease their cognitive load [5].

Spatial ability influences students' cognitive load and cognitive ability [6]. Cognitive ability is a student's spatial ability to visualize, make mental rotation among objects and convey perspectives when talking about facts [7]. Research towards virtual classroom shows the relationship between spatial ability and achievement in science education [8,9]. A thinking map simplifies a cognitive load fact into a corresponding visual aid of spatial ability [3].

Virtual classrooms act as effective students' learning visual medium [10]. It would be the best medium to enhance the millennial style and strategy of obtaining information and knowledge. A virtual classroom not only delivers course materials, but also provides an interactive learning environment [11]. The Malaysia education system needs to play a role in introducing Industrial Revolution 4.0 (IR4.0) in schools and universities such as the virtual classroom to provide students that occupy the industrial demands [12]. Apart from traditional learning, a virtual classroom [6] combines text, graphics, proper visuals and animations for active and student centered learning.

Chemistry students who are involved in animation learning show higher spatial ability compared to those in conventional classrooms or lectured classes [13]. Spatial ability could be increased through continuous training and one of its dimension was thinking map [14]. *I-think* is a thinking map learning tool [1]. *I-think* thinking maps give continuous spatial ability training for students to enhance their HOTS [2]. *I-think* maps [15] improve a student's behaviour to be more positive, focused and interested in learning. Students could easily express their understanding into structured visual context and increase their long term memory. This promotes active learning for students. Inactive learning is one of the factors that reduce students' interest [16]. Students lose their interest in learning when they cannot find the benefits or relevance of the lesson to their daily lives and cannot not communicate well the lessons among themselves.

In 2019, Google Classroom (GC) was used as a virtual learning platform in education. GC provided a platform where communication between teachers and students could occur in a millennial style, with ease and attractiveness [17]. It helped to maximize the STEM education towards 21st century learning. Information technology and communication were the skills needed for STEM students to master [4]. Moreover, teachers still had problems using technology in their lessons [18]. The students' ability to self access of learning material were not satisfied [2]. Furthermore, teachers still used lectures and referenced textbooks and notes which created boring and uninteresting lessons.

Students were not interested in learning and only learned to pass an examination [19]. Failure to inculcate students' interest produced low potential of HOTS among students, leading to low achievement in STEM courses. The surroundings was a major factor for the difficulties in providing STEM students [7]. The factors included teachers' preparation, curriculum design and the evaluation program. Recently, students cognitive ability was a significant concern in STEM education.

I-think Virtual Chemistry Classroom (ITVC) helps teachers use 21st century learning to enhance HOTS among students. This classroom also increased interest among different spatial ability students towards electrochemistry subtopics and became an early introduction for IR4.0 in education for teachers and students.

RESEARCH OBJECTIVE

Based on the background illustrated above, the objectives of this study are to

1) Develop the *i-think* virtual chemistry classroom (ITVC) on electrochemistry subtopic
2) Investigate the effect of ITVC towards

    a) Higher Order Thinking Skills (HOTS)
    b) Interest

RESEARCH QUESTIONS

The following research questions are stated to guide the study

1) What are the validity and reliability indices of the instrument and ITVC that is developed?

2) a) Effect of ITVC towards HOTS

    i) Are there any significant differences between high spatial ability (HSA) and low spatial ability (LSA) in the mean score electrochemistry HOTS achievement test for the control and treatment groups?
    ii) Are there any significant differences between LSA in the control and treatment groups in post electrochemistry HOTS achievement test?
    iii) Are there any significant differences in HOTS between LSA in the treatment group and HSA in the control group in post electrochemistry HOTS achievement test?

    b) Are there any significant differences between the pre and post interest mean score test for LSA in both the control and treatment groups?

LITERATURE REVIEW

Electrochemistry was one of the toughest and most abstract topics in chemistry because it involves macroscopic and microscopic levels that contributed to low achievement in student performance [20]. To overcome this problem, the use of multimedia presentation showed higher student thinking achievement in the organic chemistry subject that involves macroscopic and microscopic levels [21].

Thinking was the way to retain knowledge in long term memory [22]. Prior knowledge and new information accepted must be arranged in a structure and be connected to each other for production of a scheme of linking information [23]. Next, interest and connected linkage provided focus among students [24]. Focus can lead to active student involvement and an easier way to remember learning [23]. Students need to be actively involved in learning to increase student achievement [25]. In addition, student interest could be increased through effective discussion, dialogue and debate via virtual collaboration [26]. Meanwhile, problem solving and decision making that involve HOTS could effectively spread out using thinking maps [25].

Education information could be arranged using *i-think* thinking maps that ease students to visualize learning [16]. *I-think* thinking maps help students in their strategy thinking process and help students not to make decision hastily [4]. Interest shown when students could intensify their thinking towards facts could not be achieved when they are in a rush or are hurried [27]. Interest is also shown when students are actively involved in learning. They could communicate and collaborate among each other about learning [28]. Furthermore, interest was conveyed among students when they could apply and communicate together about learning in their daily lives [29]. Virtual classrooms enable students to think

actively and innovate an idea to share together [30]. Thus, learning the abstract content of electrochemistry using the combination of *i-think* learning tools and virtual classrooms were explored in this research.

METHODOLOGY

Design of Study

I-think virtual chemistry classroom (ITVC) and conventional virtual chemistry classroom (CVC) were developed based on the ADDIE and 5E instructional model. ITVC was equipped with *i-think* thinking maps while CVC was equipped with conventional comparison tables. Both control and treatment groups used Google Classroom that was provided by Malaysia Ministry of Education as a 21st century learning platform for virtual classrooms. Refer to Figure 1 for ITVC and Figure 2 for CVC interfaces.
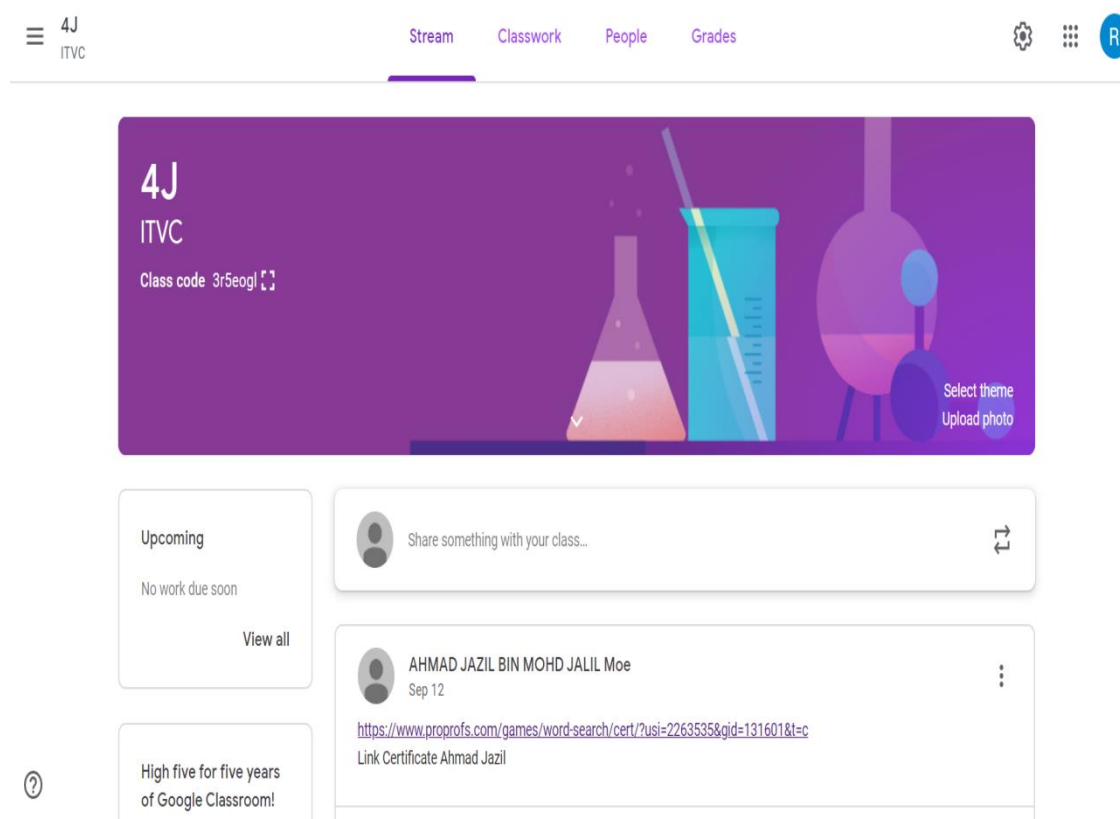

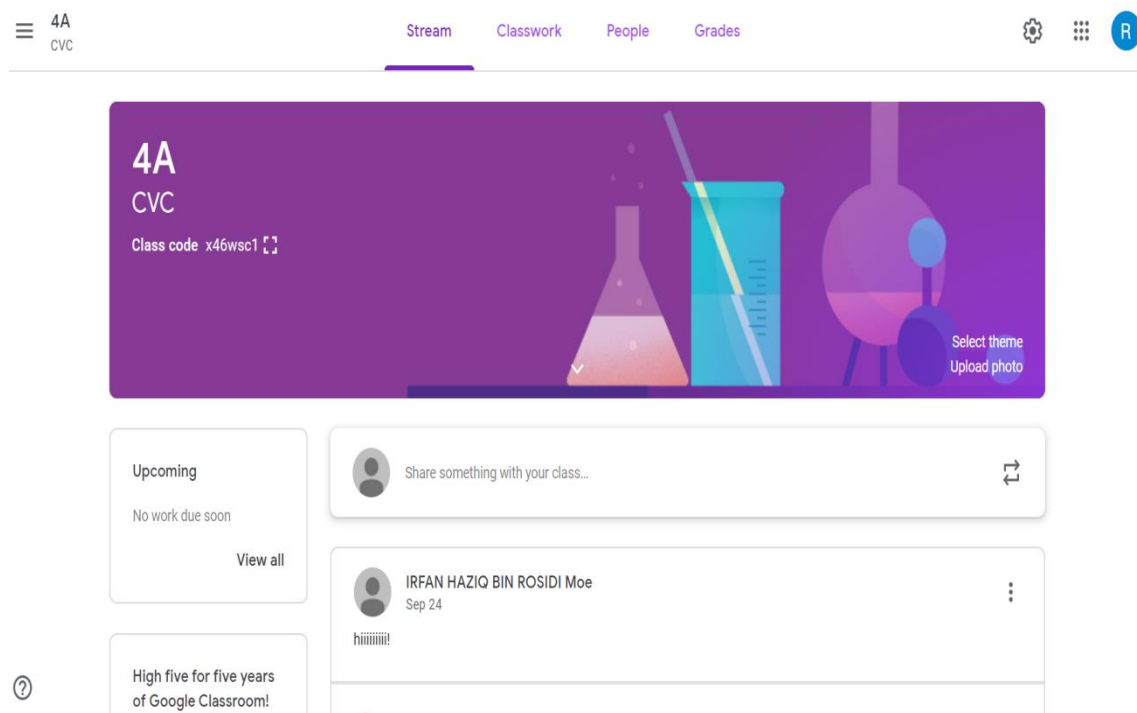**Figure 1:** *I-think* virtual chemistry classroom interface

Figure 2: Conventional virtual classroom interface

On the ADDIE model instructional system, both virtual classrooms were designed following the steps of Analysis, Design, Development, Implementation and Evaluation for the whole process of research while the 5E instructional model was the structured phase model in designing the content of the virtual classroom. On the ADDIE model, students would take a spatial ability test, pre-test for electrochemistry and interest questionnaires for the analysis phase. Next, the virtual classroom of ITVC and CVC were Design and Development based on the analysis result and expert validation. For the implementation phase, students would learn via ITVC or CVC within a month involving 3 subtopics in electrochemistry. After that, a post-test for Evaluation electrochemistry HOTS achievement and interest was taken to evaluate HOTS trends.

The 5E instructional model included five phases of learning which were Engagement, Exploration, Explanation, Elaboration and Evaluation [31] that were involved when students learned based on their ITVC or CVC. Firstly, on Engagement phase, students would view a HOTS engagement video to generate their inquiry and interest about learning outcomes. Students would make an observation and collect data via teaching and learning sessions on Exploration phase. Next, students would explain their corresponding answer on a revision module on Explanation phase. On Elaboration phase, the teacher shared a revision module test answer video and gave an additional task for students to complete. Thus, students needed to construct their own understanding of the revision module answer video and resubmit the revision module including the given task to be evaluated by the teacher. The teacher would share their corresponding marks and make comments to improve the module revision mark, if any, at the end of the lesson. They had one hour to complete the task.

This quasi experimental study was conducted with spatial ability, pre-post electrochemistry HOTS achievement and an interest test to address the research questions. The research framework is illustrated in **Figure 3** below.
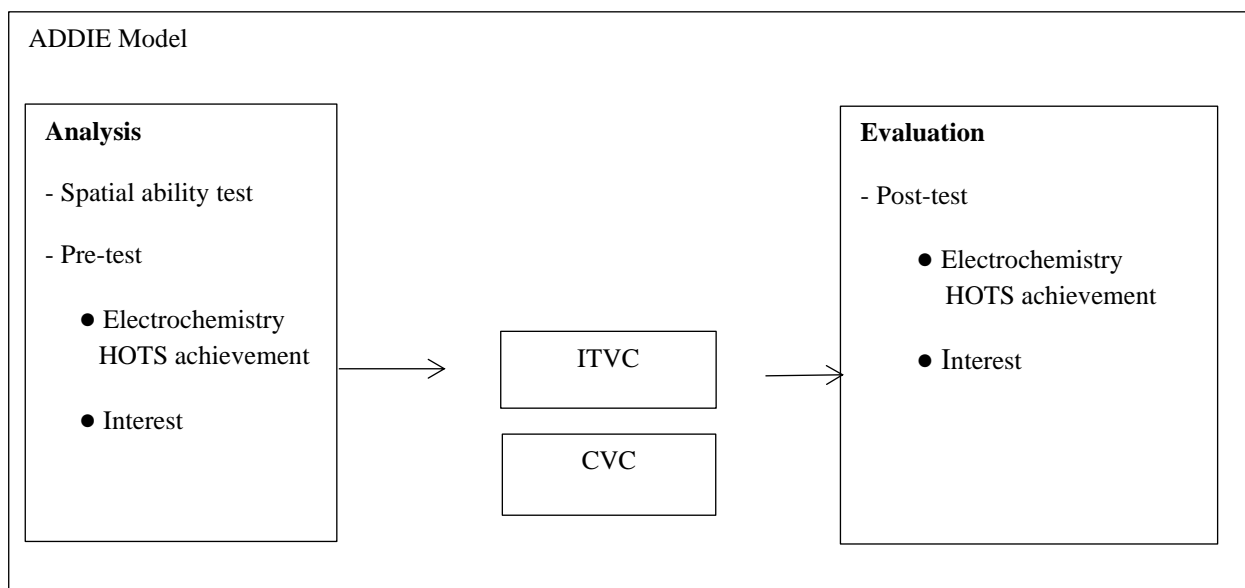
Figure 3: Research framework

Students' level of spatial ability were determined using Visualization of Rotation Test by Bodner and Guay [32]. Next, students needed to answer the pre-test to evaluate their electrochemistry HOTS achievement and interest before the virtual classroom. Two groups of selected students would learn electrochemistry subtopics using ITVC and CVC via GC platform accordingly and undergo all the 5E instructional model phases. Finally, the post test for electrochemistry and interest were given to estimate the level of HOTS and interest at the end of the lesson.
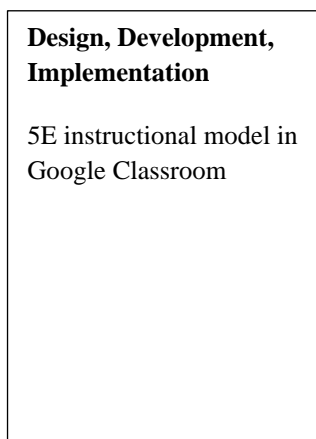
Respondents

66 of form 4 students in 4 selected classes (4G, 4D, 4J and 4A) were involved with 2 classes of 4G (5.96) and 4D (6.17) having higher cumulative grade performance achievement (CGPA) in a mid year chemistry examination compared to 4J (7.23) and 4A (7.00). Two groups were formed, with one class with low and another one class with high CGPA which were 4G, 4J as one group and 4D, 4A as the other group. Random sampling technique of bouncing coins were used to classify the learning tools using ITVC (treatment) and CVC (control) groups [33]. Thus, the group of 4G, 4J were selected as the treatment group while 4D,4A were the control group. All the students took a spatial ability test to classify their level of spatial ability. The demographic data of the respondents are summarized in Table 1 below.

Table 1: Demographic data of respondents

Group	Students	Spatial ability	N	Male	Female
Control	33	LSA	22	2	20
		HSA	11	6	5
Treatment	33	LSA	25	6	19
		HSA	8	5	3

There were 22 students with low spatial ability, LSA and 11 students with high spatial ability, HSA in the control group, while 25 students with LSA and 8 with HSA were in the treatment group. A total of 33 students were in each control and treatment group.

Instrument

Spatial ability test

All students answered 20 Visualization of Rotation Test by Bodner and Guay [32]. This test was taken using paper and pencil to determine their level of spatial ability. High Spatial Ability students were students with a higher score than the average group score while Low Spatial Ability (LSA) were students that scored lower than the average [6].

Pre-post electrochemistry higher order thinking skills achievement test

This tests involve two subjective questions and one essay question based on HOTS level for three subtopics in electrochemistry which were:

    i)   Electrolyte and non-electrolyte
    ii)   Electrolysis in aqueous solution
    iii)   Electrolysis in industries

      Questions were based on *Sijil Pelajaran Malaysia* (SPM) for electrochemistry subtopic from 2006 until 2018. The questions were modified corresponding to HOTS level of applying, analyzing, evaluating and creating. A total mark of 40 were given for each pre and post electrochemistry HOTS achievement test. Students would answer in an hour for each paper test. The item distribution based on HOTS level is shown in Table 2. Equal level of HOTS were spread around pre and post achievement tests.

Table 2: Item distribution of Pre-post test according HOTS level

Objective learning	Pre-test (Questions number)	Post-test (Questions number)	HOTS level
Application of electrolyte and non-electrolyte properties	3a)	2a)	Applying
Analysis on electrolysis of molten/aqueous solution	1a), 1b), 1c)i), 1c)ii) 2a), 2b)i), 2b)ii), 2b)iii), 2c) 3b), 3c)	1a), 1b), 1c) 2a)ii), 2a)iii), 2b)i) 2b)ii), 2b)iii), 2c) 3a), 3a)i), 3b), 3b)i),	Analyzing
Application on electrolysis of molten/aqueous solution	1d),	1e)	Applying
Evaluation on electrolysis of molten/ aqueous solution	3b)i), 3c)i)	1d)i), 1d)ii), 3a)ii)	Evaluating

| Evaluation of electrolysis in industries | 2d), 3e) | 1f), 3c) | Creating |

Interest questionnaires

There are 21 items with a 4 point scale. This interest test was given before and after the ITVC or CVC session. This test was an adaptation from Improving the interest of high-school students towards chemistry by Crime Scene Investigation [29] based on the suitability of this research. The dimensions of interest were arousal, pleasure and competence [34]. The interest test sub-dimension distribution is summarized in Table 3. In arousal, an item could be divided into internal and external interest, pleasure with ease of understanding and ease to correlate learning item, while in competence was the ability to control learning and self-determination item. A total number of 7 questions were in the arousal, pleasure and competence dimension.

Table 3: Interest questionnaires dimension distribution

Dimension	Item distribution
Arousal	
a) Internal interest	1,2,3,4
b) External interest	5,6,7
Pleasure	
a) Ease of understanding	8,9,10,11
Ease to correlate learning	12,13,14
Competence	
a) Ability to control learning	15,16,17,18
b) Self determination	19,20,21

Next, the students were divided into treatment and control groups stated above, and they learned electrochemistry based on ITVC or CVC virtual classroom prepared in this research.

ITVC and CVC Software

Learning Video

Lessons using video increase student focus [35]. A virtual classroom helps students visualize learning and increase thinking skills as well as their focus [6]. Lessons using video were used in these virtual classrooms. Both ITVC and CVC developed using the *Screencast o matic* application, laptop screen video recording of Microsoft Power Point windows 10 slide presentation and background audio of the teacher's voice. The slide presentation used *I-think* thinking maps for ITVC and comparison tables for CVC in all three subtopics. Three learning videos for the subtopic were prepared for each virtual classroom. Both virtual classrooms also consisted of Revision Module to enhance their understanding about the learning of electrochemistry.

Revision Module

Revision Module included all the three subtopics mentioned for both ITVC and CVC. The Module consisted of subjective questions using the Google Slide application. Students needed to answer the module online and the teacher could view student progress and respond to students' answers. Students could also asked the teacher when they faced any problems when answering the Module using the chat column. ITVC Revision Module used *i-think* thinking maps while CVC used comparison tables, and fill in the blank or sequence numbers that normally are practiced in class. The test specification table for the Module is summarized in Table 4.

Table 4: Test specification table for ITVC and CVC in Revision Module

Subtopic	Item	HOTS Level	ITVC	CVC
Electrolyte and	1	Applying	Double bubble map	2 X 4 table
Non-electrolyte	2 a i)	Evaluating	Brace map	Fill in the blanks
	2 b)	Analyzing	Flow map	3 X 6 table
	3	Creating	Flow map	Sequence number
Electrolysis in aqueous	1	Analyzing	Flow map	3 X 7 Table
solution	2	Analyzing	Flow map	3 X 7 Table
	3	Evaluating	Flow map	3 X 7 Table
	4	Creating	Flow map	3 X 7 Table
Electrolysis in	1	Analyzing	Flow map	3 X 7 Table
industries	2	Evaluating	Flow map	3 X 7 Table
	3	Creating	Flow map	3 X 7 Table

The Revision Module was followed the HOTS level of applying, analyzing, evaluating and creating [1]. In ITVC, three types of *i-think* thinking maps were used which were double bubble map, brace map and flow map while CVC used conventional thinking learning that were comparison tables of 2X4, 3X6, 3X7 tables, fill in the blanks and sequence number questions. A Revision Module Answer video was provided to guide students to answer each question in the module. In addition, the teacher also was given an extra task to be completed in the Revision module answer video to enhance student understanding. The validity and reliability of the Module were measured to ensure the usability of the module.

RESULTS AND DISCUSSION

1) Validity of Instrument, ITVC and CVC virtual classroom

Validity of instruments were analyzed using the Content Validity Index, CVI, while Cohen Kappa coefficient was used to validate content and multimedia sustainability for ITVC and CVC virtual classrooms. Research [36] reported the use of CVI to determine the average degree of approval between experts. The validity of CVI value accepted was ≥ 0.80 [37]. According to Table 5, interest questionnaires scored a CVI value of 0.92 among 7 experts, electrochemistry pre-test scored 0.86 while electrochemistry post-test 0.84. All the instruments could be used in this research to determine the construct and dimension involved.

Validity for ITVC and CVC software were validated using degree of approval, the Cohen's kappa coefficient between two experts. Research by [38] reported that Cohen's kappa coefficient $\kappa > 0.80$ shows a high degree of approval and was valid to be used in research. For ITVC, the kappa coefficient was $\kappa = 0.84$ for content, $\kappa = 0.83$ for multimedia, while in CVC, it was $\kappa = 0.85$ for content and $\kappa = 0.83$ for multimedia. Thus, both ITVC and CVC could be used in this research with a high level of validation coefficient.

Table 5: Validity for instrument, ITVC and CVC software

No	Instrument	CVI Validity			Level		
1	Interest test	0.92			High		
2	Electrochemistry achievement pre-test	0.86			High		
3	Electrochemistry achievement post-test	0.84			High		
		ITVC Cohen's kappa coefficient			CVC Cohen's kappa coefficient		
		Content	Multimedia	Level	Content	Multimedia	Level
4	Virtual classroom	0.84	0.83	High	0.85	0.83	High

Reliability of Instrument, ITVC and CVC software

Reliability instrument of pre-post electrochemistry HOTS achievement and spatial ability test which were dichotomous scoring were validated according to *Kuder-Richardson KR-20* index. Thw interest test which used likert scale involving more than two choices were validated according to *Cronbach's Alpha* index. The reliability alpha and KR-20 index > 0.70 shows that the instrument could be used [39]. All four instrument score alpha indices were > 0.70 with electrochemistry HOTS achievement pre-test 0.724, electrochemistry HOTS achievement post-test 0.777 spatial ability test 0.769 and interest questionnaires 0.925. The KR-20 and Cronbach's Alpha reliability indices are summarized in Table 6.

Table 6: Reliability of research instrument

Instrument	Nilai KR-20/ *Cronbach's Alpha*
Electrochemistry achievement pre-test	0.724
Electrochemistry achievement post-testa	0.777
Spatial ability test	0.769
Interest questionnaires	0.925

Reliability of ITVC and CVC virtual classroom software were determined using test retest reliability index. The correlation coefficient (r) $\geq$ 0.70 shows all the items were suitable to be used [40]. Pearson correlation for ITVC students (N = 33) in the Revision Module in subtopic 1 (M = 68.48, SP = 4.757) with subtopic 2 (M = 71.82, SP = 7.269) was r = 0.72, while with subtopic 3 (M = 66.52, SP = 7.233), it was r = 0.84. Furthermore, the correlation coefficient for subtopic 2 and 3 was r = 0.75. On the other hand, for CVC students (N = 33) the correlation coefficient between subtopic 1 (M = 70.00, SP = 5.995) with subtopic 2 (M = 68.94, SP = 4.802) was r = 0.79, while with subtopic 3 (M = 68.64, SP = 5.042), it was r = 0.75. The correlation coefficient between subtopic 2 and 3 for CVC students shows the correlation coefficient value to be, r = 0.81. All the correlation coefficient values scored higher than 0.70 at a significant level $p < 0.05$. Thus, both ITVC and CVC virtual classrooms could be used in this research. The correlation value of test-retest for the subtopics are summarized in Table 7 below.

Table 7: Reliability of test retest correlation coefficient for ITVC and CVC software

Virtual Classroom	Subtopic	Mean	SD	Subtopic 1 (r)	Subtopic 2 (r)	Subtopic 3 (r)
ITVC	Subtopic 1	68.48	4.757	1.00	0.72	0.84
	Subtopic 2	71.82	7.269	0.72	1.00	0.75
	Subtopic 3	66.52	7.233	0.84	0.75	1.00
CVC	Subtopic 1	70.00	5.995	1.00	0.79	0.75
	Subtopic 2	68.94	4.802	0.79	1.00	0.81
	Subtopic 3	68.64	5.042	0.75	0.81	1.00

Significant if $p < 0.05$

A refinement process was done according to an expert suggestion to minimize errors. Next, Implementation phases were done to answer all the research questions based on HOTS and interest.

2 a) Effect of ITVC towards students' higher order thinking skills achievement

i) **Are there any significant differences between high spatial ability (HSA) and low spatial ability (LSA) in mean score electrochemistry HOTS achievement test for control and treatment groups?**

Table 8: Analysis of paired sample t-test in pre-post electrochemistry HOTS achievement in group

Group	Spatial ability	Test	Mean	SD	t	p
Control	LSA	Pre	23.86	13.014	-10.406	0.000
		Post	45.45	15.931		
	HSA	Pre	34.67	16.670	-6.081	0.000
		Post	60.27	17.967		
Treatment	LSA	Pre	32.64	16.738	-8.027	0.000
		Post	56.92	13.404		
	HSA	Pre	49.00	21.541	-8.040	0.000
		Post	69.13	18.059		

Significant if p < 0.05

Table 8 shows paired sample t-tests for LSA and HSA in pre-post electrochemistry HOTS achievement for control and treatment group analysis. In the control group, LSA t(21) = 10.406, p = 0.000 and HSA t(10) = 6.081, p=0.000, while LSA t(24) = 8.027, p = 0.000 and HSA t(7) = 8.040, p = 0.000 in the treatment group (significant if p < 0.05). In short, LSA and HSA show higher post electrochemistry HOTS achievement for both control and treatment groups. There was no significant difference among LSA and HSA in mean score electrochemistry HOTS achievement for both groups. This supported research by [30] that a virtual classroom made students actively think and increase their HOTS achievement. This contradicted research by [13], which reported that students learning by using animation in a virtual classroom using a smart phone showed low achievement compared to a conventional classroom. This research using GC prepared by Malaysia Ministry of Education and students using chromebooks provided to help student focus on learning without any outside interruption, proved that students somehow need an appropriate platform to control learning.

Table 9: Analysis of independent sample t-test among LSA in treatment and control group towards pre-post electrochemistry HOTS achievement test

Test	Group	Mean	SD	t	p
Pre	Treatment	32.64	16.738	1.986	0.053
	Control	23.86	13.014		
Post	Treatment	56.92	13.404	2.446	0.018
	Control	46.45	15.931		

Significant if p < 0.05

ii) Are there any significant difference between LSA in control and treatment groups in post electrochemistry HOTS achievement test?

Table 9 shows independent sample t-tests among LSA in treatment and control groups towards pre-post electrochemistry HOTS achievement test. It proved that there was no significant difference between LSA in pre test t(45) = 1.986, p = 0.053 in both control and treatment groups but there was a significant difference for both groups in post test t(45) = 2.446, p = 0.018. The findings revealed that LSA in the treatment group performed better when they were involved in ITVC. Thus, ITVC benefits LSA in the treatment group by increasing their electrochemistry HOTS achievement. This result supported findings by [6,19] that showed visualization gave noticeable influences for low achievement students in learning. LSA needs visualization learning aids to enhance their electrochemistry HOTS achievement. Thus, *i-think* thinking tools would be the best choice of learning aid.

Table 10: Analysis of independent sample t-test among HSA in control and LSA in treatment group towards post electrochemistry HOTS achievement

Group	Spatial ability	Mean	SP	t	p
Control	HSA	56.92	13.404	-0.622	0.538
Treatment	LSA	60.27			

Significant if p < 0.05

iii) Are there any significant difference in HOT between LSA in treatment and HSA in control group in post electrochemistry HOTS achievement test?

Results in Table 10 show the analysis of independent sample t-tests among LSA in control and HSA in treatment groups towards post electrochemistry HOTS achievement. There was no significant difference between both groups in spatial ability t(34) = 0.622, p = 0.538. Hence, it was interesting to identify that achievement for LSA in the treatment group was equivalent to the HSA in the control group. The findings reported that HSA shows higher achievement compared to LSA students, but this finding supported by [6] that achievement of LSA in biology cell were equivalent with HSA students after the virtual classroom treatment using visualization aids. Thinking maps help students visualize better [5]. Furthermore, *i-think* thinking maps ease students visualized in learning [16]. Likewise, the treatment of ITVC made higher improvement for electrochemistry HOTS achievement among LSA students.

2 b) Effect of ITVC towards students' interest

Table 11: Analysis of paired sample t-test for pre-post interest test

Group	Spatial ability	Test	Mean	SD	t	p
Control	LSA	Pre	2.49	0.433	-3.194	0.004
		Post	2.68	0.426		
	HSA	Pre	2.44	0.166	-3.804	0.003
		Post	2.68	0.312		
Treatment	LSA	Pre	2.59	0.475	-4.850	0.000
		Post	2.84	0.379		
	HSA	Pre	2.96	0.322	-2.116	0.072
		Post	3.15	0.395		

Significant if p < 0.05

Correspondent analysis in Table 11 revealed that the interest mean score for LSA in control t(21) = 3.194, p = 0.004 and LSA in treatment t(24) = 4.850, p = 0.000. LSA in both groups shows higher interest in electrochemistry virtual learning. Meanwhile, HSA in control was t(9) = 3.804, p = 0.003 and HSA in treatment was t(24) = 2.116, p = 0.072. This indicated that HSA in the control group shows higher interest after the learning but not for the HSA in the treatment group. Further analysis between groups were investigated to find the differences.

Table 12: Analysis of independent sample t-test for interest among high spatial ability students

Interest test	Group	Mean	SD	t	p
Pre	Control	2.44	0.166	4.575	0.000
	Treatment	2.96	0.322		
Post	Control	2.68	0.312	2.935	0.090
	Treatment	3.15	0.395		

Significant if p < 0.05

Table 12 shows there was a significant difference in post test t(17) = 2.935, p = 0.090 but not in pre test t(17) = 4.575, p = 0.000. A high mean score in treatment (M = 2.96, SD = 0.322) compared to the control group (M = 2.44, SD = 0.166) in pre-test revealed the unsuspected finding of HSA in the treatment group.

High mean score pre interest test value causes only small increment in post interest test in treatment group compare to the control group. In fact, both LSA and HSA students performed with a higher interest after the ITVC learning session. *I-think* thinking tool increased student behaviour, focus and interest towards learning [15]. Learning using spatial ability training such as thinking maps increased student interest in STEM education [14]. P

CONCLUSION

The growing recognition of spatial thinking skills for STEM achievement began to show its importance in education standards. Students need to develop their spatial thinking skills to establish their HOTS in learning. *I-think* learning maps inculcate thinking skills and interest among STEM students. This research implies LSA and HSA students could enhance their HOTS and interest in electrochemistry via ITVC. Virtual learning and *i-think* thinking maps act as an effective catalyst to increase HOTS and interest among millennial chemistry students.

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