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A Preliminary Study on the use of Mind Mapping as a Visual-Learning Strategy in General Education Science classes for Arabic speakers in the United Arab Emirates

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Abstract: Mind mapping was introduced as a culturally relevant pedagogy aimed at enhancing the teaching and learning experience in a general education, Environmental Science class for mostly Emirati English Language Learners (ELL). Anecdotal evidence suggests that the students are very artistic and visual and enjoy group-based activities. It was decided to integrate an intervention that would incorporate Emirati artistic and collaborative practices, in an effort to engage them on all levels, such that their academic attainment is positively affected. Preliminary results based on a group of 60 students, from on-going active research, suggest that this method is quite useful in helping pupils summarise lengthy lessons and increase student engagement and communication amongst peers, which helps them to reinforce scientific theories and concepts. This method further facilitates on-the-spot identification of misconceptions that students may have, as the instructor can proffer an immediate feedback. Students seem more responsive and motivated as they positively contribute to their learning environment, which is believed can only further strengthen their internal locus of control. The results satisfy paucity in the literature on effective pedagogic strategies for Arabic ELLs in science

Keywords: mind mapping, Arabic English language learners, environmental science, science education

Introduction

The teaching environment at this Middle Eastern university, and most other universities in the Gulf region for that matter, is one in which students are taught by mainly expatriates. These English Language Learners (ELLs), sometimes struggle with understanding instructions given by a culturally diverse, mostly native English speaking, faculty. Such a learning environment may prove to be very daunting for many, as these students are required to learn through the vehicle of a yet-un-mastered language (Hart & Lee, 2003). If students lack the required literacy development in English, then they will more than likely encounter academic learning difficulties that will thwart their participating and ultimately their learning in science lessons (Lee & Fradd, 1996). It is further believed that these types of constraints may result in reduced academic attainment in science for ELLs, when compared to their English-speaking peers (NCES, 2000).

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This was one of the concerns that science professors at a university in the United Arab Emirates were experiencing. The students at the institution were mainly Arabs with a large percentage of them being novice ELLs, and almost all were non-science majors. Assessment results and overall classroom observations revealed low comprehension among the students in the science courses. This was coupled with lack of retention and transferability. Rote learning and reduced critical thinking were also noted. Students were oftentimes fatigued, frustrated and demotivated with having to study a science course taught in a language they struggle to learn in an area they are highly unlikely to major in.

The aim therefore was to find best practice methods suitable for ELLs that would accomplish the following:

- Increase student engagement.
- Increase student comprehension and performance.
- Encourage students towards intrinsic motivation and science self-efficacy.
- Incite critical and analytical thinking.
- Stimulate interest in learning science.

Further to having these outcomes, the instructional techniques should provide a meaningful context for English language and literacy development, which would provide the medium for engagement with scientific content (Lee, 2005). It has been proposed that some of the best methods to teach science to ELLs include:

- Collaborative small group activities, which would afford structured opportunities for developing English proficiency in the context of genuine communication about scientific knowledge.
- Hands-on activities, which are less dependent on the formal mastery of language and therefore reduce the linguistic burden on students (Lee, 2002).

Research that was done to ascertain what were the best teaching practices that would be fitting for Arabic ELLs (Jewels & Albon, 2012), recommends that while teachers should be aware of the language differences and student difficulties, one should also be aware of how the native culture may impact teaching and learning. Local Arab students have expressed that they believe the following techniques help them to learn best (Jewels & Albon, 2012):

- Use of easy English terms.
- Use of basic English language.
- Repeating information.
- Summaries of lesson.

General observations of the students' work clearly depict how artistic local students are. The use of art is proudly displayed in all facets of their lifestyles, it is very common to see murals and architecture with very intricate Arabic calligraphy designs, which is a practice that is believed to mix spiritual meaning with aesthetic beauty (Moustapha & Krishnamurti, 2001). Projects and cultural displays done at the University are generally made with very detailed drawings and illustrations. Coupled with this artistic means of expression, anecdotal evidence shows the collaborative nature of the students, especially the males. Collaboration is an aspect of the Arabic culture where decisions are made by group consensus in respective families and communities. It was decided that these skill sets of the students could be utilized by incorporating it within a pedagogic intervention in our ELLs' classroom. According to Lee and Fradd, (1998), an understanding of the cultural congruence, and its inclusion in teaching intervention, is imperative with students not proficient in the language.

The task at hand was therefore to find an instructional method that surrounds the students' cultural practices, in an effort to get them engaged and interested, and that would be able to act as a foundation for creating sound scientific knowledge and development. This

underscores the social constructivist approach that focuses on active learning within groups, where individuals form and construct knowledge by assigning personal meanings to it after making logical deductions based on peer interactions in the form of questioning and discussions (Akinoglu & Yasar, 2007). The learners are able to make connections between their background and new information and in so doing construct mental representations that facilitate learning. Knowledge construction is also aided by visual tools that help to organise students' prior knowledge, and incorporates the processing and understanding of new information (Evrekli, Balim, & İnel, 2009). Social constructivist learning theory emphasizes the use of questioning, critical thinking, problem solving and active participation among peers. Some researchers suggest that a constructivist-learning environment makes the classroom flexible and relaxing and this enables students to develop autonomy over their learning (Driscoll & Driscoll, 2005; Slavin, 1990).

Mind Mapping

Mind mapping in the simplest sense, is a visual tool that is used to organize information. First popularized by the psychology author Tony Buzan, it was developed over 30 years ago as a note-taking and summarization method that maximized on the different functionalities of the two halves of the brain. The left side of the brain is responsible for words, logic, sequences and analysis while the right side carries out tasks that are associated with colours, emotion, shapes and imagination. Mind mapping uses both sides of the brain and so processing productivity will be increased which translates into greater retention (Buzan, 1976).

In mind mapping, there is usually a single concept, around which ideas, images and words are added. Major ideas are directly connected to the central concept and supporting ideas branch out from major ideas radially from this central theme (Eppler, 2006). Mind maps are created by first placing the main topic in the centre of a page or screen. Connecting lines that radiate from the central word creates branches. These are known as sub-topic branches and each represents a single idea that is directly related to the main topic. Users may find it useful to colour code the sub-topic branches. Sub-branches can then be added to these branches to give more detailed explanations of the key ideas and concepts. Pictures and diagrams can be inserted to further expound upon ideas. The principle is that ideas should move from the abstract to the more concrete (Meier, 2007). Mind mapping is suitable for visually representing data in an open flowing format that supports the natural thought process and creativity of individuals. The visually pleasing nature of mind maps with its use of colours and pictures would make it a suitable tool to create interest in our mostly artistic students, to increase their engagement during class time. Also, this visual appeal is expected to boost memorization and recall, which would speed up the learning process (Brinkmann, 2003).

Zhao believes that mind mapping is a pedagogic technique that supports a constructivist learning theory, especially in an Environmental Science class (Zhao, 2003). The results of the study suggest that mapping techniques are able to make the students' learning a process of sense-making and of adding and combining new information within existing knowledge structures, which has proven to be beneficial to the teaching of Environmental Science. Building from this, it is believed that mapping might be a useful tool to teach Environmental Science to Arabic students. This was strengthened when one takes into consideration the proposition from Harper and Jong, that the use of graphic organisers, such as mind maps, help to reduce language demands on ELLs (Harper & Jong, 2004). This would be highly beneficial in an English language learning science classroom such as ours, as students will be given the opportunity to focus on the main objectives of the class without the constraints of focusing on elaborate sentence construction, yet at the same time develop relevant vocabulary. It is also

believed that visual representations reinforce the spoken word and aid with comprehension when teaching students in a language that they are still learning (Peters & Davis, 1998). The consideration for using this visual technique is that mapping is considered an active learning technique that enables the instructor to give prompt feedback and respects diverse talents and ways of learning. Active learning techniques recognize that individuals have to engage with the content and with others, unveil prior ideas, make connections between ideas, and construct new knowledge from their experiences (Ueckert & Gess-Newsome, 2008). According to Grant et al, another good teaching practice is one in which teachers get students to manage their time productively and organise their knowledge (Grant, Rubash, & Neelly, 2005). Again, mapping achieves these objectives. Generally, mapping methods seem to be good graphical tools to employ, as its general features can be considered to be synonymous with what has been defined as good teaching practices (Chickering & Gamson, 1999). For Example:

- Encourages contacts between students and faculty.
- Identifies gaps in student understanding.
- Facilitates prompt feedback.
- Respects diverse ways of thinking.
- Utilises an active learning technique.

Further to this, it is a common belief that if students can draw diagrams to show complex relationships of a concept by critically analysing the ideas that make up this concept, then they will be better able to understand and remember them (Biggs, 1987). This sort of activity will promote a deeper level of approach to the learning process. Greater learning would also be achieved; concept maps are heuristic and so students are able to identify and amend their misconceptions (Czerniak & Haney, 1998). Researchers have shown that visual displays may play a key role in the learning process (Vekiri, 2002). Also, pictorial knowledge representations are thought to help students self regulate their learning by externalizing what their thoughts are and to see what others are thinking (Näykki & Järvelä, 2008). Generally, pictures and structured diagrams are more comprehensible than just words, and are better able to illustrate complex topics (Davies, 2011). This would be extremely beneficial for implementation in our ELL classrooms. The use of mind mapping in nurse practitioner education supports enhanced memorisation of concepts. It was found that mind maps are creative ways for students to engage in a unique method of learning that can expand memory recall of key topics and help create a new environment for processing information (Spencer, Anderson, & Ellis, 2013).

Mind mapping has also been shown to improve students' grades in science (Abi-El-Mona & Adb-El-Khalick, 2008). The grades of students that used mind mapping, from a post-instruction achievement test, were on average, higher than the control group. Coupled with that, the experimental group achieved statistically significant gains on target categories such as conceptual understanding and practical reasoning. In a medical class in which mind mapping was introduced (Edwards & Cooper, 2010), it was found that mapping was a useful teaching resource as it served to help the instructor to prepare and review lectures. Notes could be written briefly by students, which they could review quickly at a later date, to easily make corrections or modifications. The versatility of mind mapping was seen when it was employed in a school's library media class (Goldberg, 2004). The study proposed that mapping is a skill that is applicable across ability levels of students and encompasses all subject matters (Anderson, 1993). Mapping in the media class was found to have been instrumental in note taking, planning and organising information, hence learners were better able to use the information they had acquired. Anderson (Anderson, 1993a) proposed that mind mapping enhances the use of the imagination during the creative processes of marketers. In another study that looked at the

reception of students and teachers to the use of mind maps in a science class (Goodnough & Woods, 2002), it was found that both teachers and students enjoyed using mind maps. The teachers believed using mind maps fostered student motivation in wanting to learn science.

Jewels and Albon (2012) reported on some instructional techniques they thought necessary to successfully instruct Arabic learners. Based on the information presented on the benefits of using mapping techniques, mind mapping seems ideal in fulfilling these needs of Arabic learners. Mind maps are concise and would therefore provide a summary of the lesson for our ELL students, in which simple English vocabulary can be incorporated. The ease with which these summaries can be done would facilitate repetition of key ideas and concepts, which along with the visual appeal of the maps, may help to assist the students with memorisation and recall. Having the students participate in such an active learning activity may also be beneficial for improving their engagement and ultimate motivation in wanting to study a science course, even the ones who are non-science majors. This paper hopes to assess the effectiveness of using mind maps as a pedagogic tool, for enhancing the learning outcomes for Arabic ELLs studying in a science course. The questions being addressed are:

- What are Arabic students' perceptions of using mind maps?
- What can instructors learn from using mind maps with Arab speakers of English in a General Education science class?

Research Methodology

Background and Context

The research was done in a Middle Eastern tertiary institution where men and women are taught separately due to cultural norms. The preliminary study was conducted in the first semester of the academic year 2014/2015. This course is a part of the colloquy programme of the university geared towards general education. Being a core curriculum course it is mandatory for all students regardless of their major. However, sometimes, due to a fear of sitting a science course or procrastination, some students postpone taking this course, for as long as they can, sometimes even to the end of the major.

The participants

The study used a convenience sample, N=60, 30 males and 30 females. The sample selection was based only on the class assignment of the investigators. Ten (10) of the male students were enrolled in the general education programme, while the other twenty-one (20) were completing their majors. None of the major students were specialising in environmental or pure science. For the females, all students were registered in the general education programme. All students were English language learners, with a minimum International English Language Testing System (IELTS) score of 5, albeit with different degrees of fluency. Two expatriate instructors taught the science modules. The instructors shared the same background, specialization, culture and ethnicity, and had previously worked together in their home country.

Study Design and Data Collection

This study employed an action research methodology approach. Action research is defined as a process of inquiry carried out by the persons doing the action (Sagor, 2000). One of the purposes of this type of research is for instructors to be able to assess their teaching

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interventions in order to improve or refine their method (Korbin, 2014). The researchers sought mainly to investigate whether the learning experience in an Arabic ELL setting could be enhanced, by using mind maps as an instructional tool. From this backdrop, the methods utilised to achieve the research objectives were as follows:

- Students were introduced to the mind mapping technique through discussion and practised during a class activity. Mind mapping was done on two out of four units in the course, namely Biodiversity and Air Pollution.
- Students were taught a particular topic from the unit for 30 minutes out of a 50-minute class period and then they were placed in groups of two or three individuals.
- Whilst in their groups, they were asked to interact with and observe the prompting material found in the PowerPoint slides; which included diagrams, photos, videos and text.
- Students were asked to list what they believed were the relevant features or key concepts on the particular topic, for example, Greenhouse Effect and Global Warming.
- Brainstorming was done in groups on how ideas would be represented.
- Students then drew and annotated a mind map on the topic.
- The students were encouraged to discuss their maps with other groups to foster communication and build each other's knowledge by listening and critiquing each other.
- Data concerning students' opinions about the use of mind mapping were gathered at the end of the semester using a questionnaire. The questionnaire consisted of 10 items measured using a Likert scale where response choices varied from *Strongly Disagree* to *Strongly Agree* as well as open-ended questions.
- The 10 Likert items were phrased as positive statements so then the answers 'Strongly Disagree' to 'Strongly Agree' were scored from one (1) to five (5) respectively, based on the premise that the underlying construct of perception lies on a continuum. Thus, the highest possible score of 50 would indicate that the student unequivocally perceived mind mapping as a useful learning tool. Whilst the lowest possible score of 10 would indicate the contrary. The Likert items were placed into two sections – each subscale designed to unearth the behaviours that should highlight the underlying construct. The first section consisted of 4 items, which were constructed to elucidate information concerned with whether students found mind maps useful. Subsequent to this section, the 6 items in the second section were constructed to determine the ways that students found mind mapping to be helpful.
- To corroborate the information gathered using the Likert items on the questionnaire, open-ended questions sought to obtain information about the perceived disadvantages of using mind maps as a learning tool and to capture any other comments that the students wanted to share about their experience using the technique.

Data Analysis

The maps were assessed via a rubric (Appendix 1) that was adapted from one previously used to assess concept sketches (Johnson & Reynolds, 2005). The rubric covered key points of the topics and the relationships between ideas. Students were assessed on their comprehension level in order to inform additional learning. The rubric was used primarily to elucidate learning gaps and not to provide summative feedback.

The mind maps that were created were later evaluated for emerging themes, which were used as a gauge to determine the relevance of the technique in an ELL classroom in enhancing

student learning. The usefulness of the technique was also assessed using the teachers' field notes on observations of student engagement and interactions. The student feedback based on the Likert items was entered in SPSS version 16.0 for Windows in order to determine each of the following:

- *Internal reliability.* Internal reliability was calculated using Cronbach's α statistic for the overall scale as well as for each subscale. The scale was deemed internally reliable if it had a Cronbach α of at least 0.7 (Cunningham-Myrie, Royal-Thomas, Williams-Green, & Reid, 2009).
- *Difference in perceptions.* Comparing the perceptions concerning the usefulness of mind mapping for the two classes was performed using a *t*-test after classifying gender as dichotomous groupings. The mean scores that were compared using the *t*-test were the mean summative scores for each grouping determined after the total score for each participant was calculated.
- *Construct validity.* Construct validity was tested by using the technique of exploratory factor analysis where the number of factors that were retained was determined using Kaiser's rule of thumb and by assessing a scree plot. Factor loadings were rotated using *Varimax* rotation so as to readily interpret the findings and loadings greater than or equal to 0.5 would be considered relevant to the interpretation of the factor (Suhr, 2006). This was done initially for each subscale and then for the overall scale.

Results and Discussion

General observations showed that students spent more time on activities; they were very motivated and involved. The use of mind maps seemed to have been enjoyed by the majority of our students, both male and females. There was an increase in the amount of time spent on task, and it was not unusual to have students staying behind after class to finish drawings or discussing mind maps. Students could be seen comparing their maps with each other and frequently made adjustments when they believed that key points were omitted. Students could be heard using more scientific jargon appropriately and code-switching between Arabic and English, when explaining ideas to colleagues who had not grasped a topic as quickly or needed further clarification.

How they drew

The students' diversity in learning styles was clearly accommodated by the use of mind maps. Given free reign, some students utilised paper and pencil (see Figure 1), while others opted for mobile applications with which they could explore the use of colours and pictures (Eppler, 2006) (see Figure 2). The mobile applications were used with devices such as the iPad and mobile phones. The most common applications used to create the maps, were SimpleMind and Inspiration.

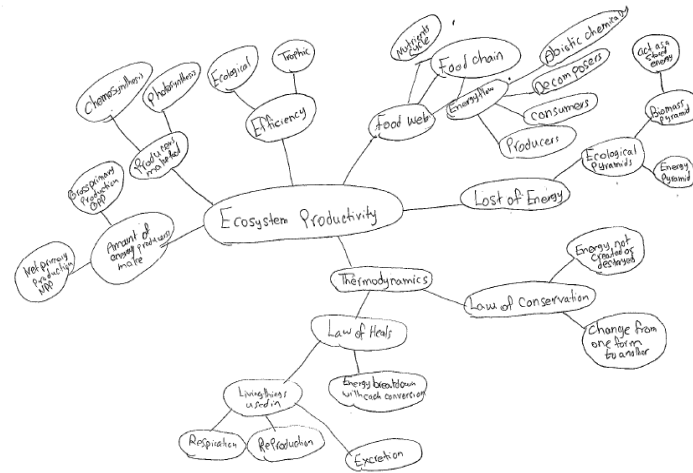


Figure 1. Example of a student’s paper-drawn mind map.

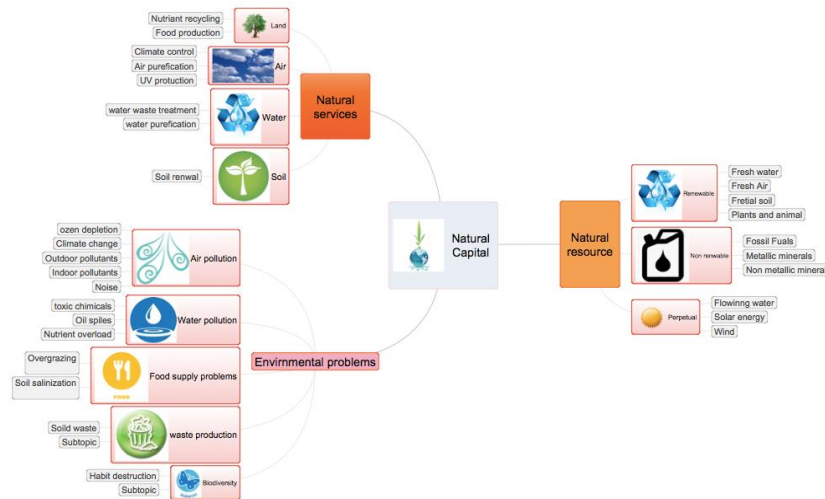


Figure 2. Student’s computer-generated mind map.

What they drew

Though the technique was originally used as a revision exercise, some students started using the technique to take notes during class, even though detailed slides are made available on the online student portal. The ease with which they are drawn, and the sparse use of nontechnical vocabulary and elaborate sentence construction, makes them useful as quick summaries. Using mind maps, students were able to focus on technical vocabulary pertinent to the science class, without having to consider complex sentence structure and grammar (Harper & Jong, 2004). The students were able to focus on selecting the main ideas that were required for effectively summarising the lesson. This is one of the ways in which students guide and direct their own learning (Leopold & Leutner, 2012). Some students however, chose to elaborate on each main idea by writing brief paragraphs on key ideas.

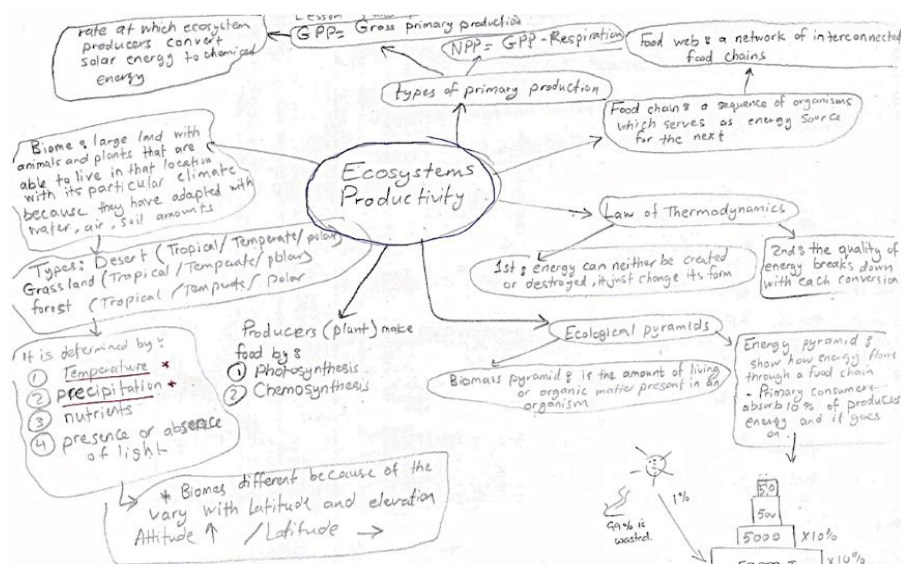


Figure 3. Elaborate student mind map.

Students' Misconceptions and Gaps in Understanding

From the mind maps it was easy for instructors to see when students' understanding were incomplete or inaccurate. For example, in one of the maps studied, the student attributed smog to be the cause of the depletion of stratospheric ozone. There was obviously some confusion on the student's part between aspects of photochemical smog and ozone layer depletion, both of which had been taught in the same unit. It became obvious that the student did not clearly understand that tropospheric ozone is a secondary pollutant in photochemical smog; there was a misunderstanding in regards to the formations and functions of tropospheric and stratospheric ozone in relation to air pollution. Having the students create mind maps enabled opportunities for prompt feedback especially in a case like this, which according to Jewels and Albon (2012), was one of the methods Arabic students feel would best support their learning experience. Although some misconceptions can be readily identified, gaps in students learning were also highlighted, which enabled intervention before the summative assessments. Figure 4 clearly shows a mind map with very little information. When types like these were observed, the opportunity was used to determine whether the student had genuine gaps in understanding or opted not to carry out the exercise. Either way, it helped the instructor to gain a better understanding on the happenings inside of the classroom.

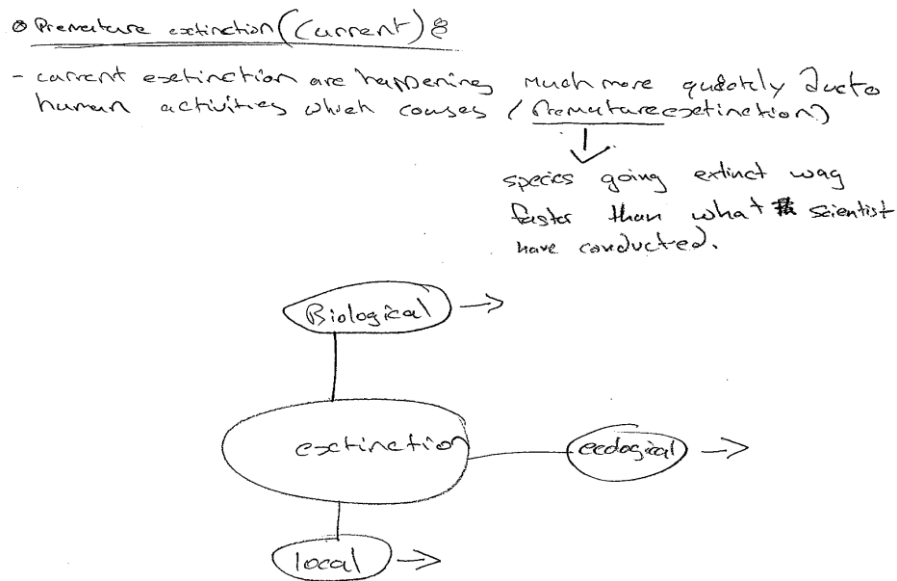


Figure 4. Sketchy mind map.

Student Responses

Internal consistency for the entire instrument as well as for each subscale were tested using Cronbach’s alpha reliability coefficient (α). Table 1 provides the values for the total items (10) and each subscale. It was concluded that the internal reliability was excellent ($\alpha \geq 0.9$) for the overall scale and acceptable ($0.7 \leq \alpha < 0.9$) for the two subscales.

Table 1. Cronbach’s alpha (N = 58)

Cronbach's Alpha (α)	N of Items
.910	10
.895	4
.847	6

The response scale used for the entire instrument consisted of a 5-point scale from “Strongly - Agree” (5) to “Strongly Disagree” (1). For this scale, higher scores were indicative of students’ perceptions of mind mapping as being helpful and lower scores of mind mapping not being helpful. Consequently, the classification of “Positive Responses” was created based on the options of “Strongly Agree” and “Agree”. The mean and standard deviation in the responses for each item as well as the summative statistics for the aforementioned classification are detailed in Table 2. Figure 5 illustrates the associated bar charts for the distribution “Positive Responses” and “Negative Responses”.

Table 2. Summative measures for the responses to each item (N = 58)

Items	Mean	Standard Deviation	Number of Positive Responses
Subscale 1 – “Was mind mapping helpful?”			
1 Mind maps are useful.	4.14	1.083	43
2 Mind maps are easy to create.	4.09	0.996	42
3 Mind maps are fun to create.	4.09	1.031	44
4 Mind maps make Science easier.	4.02	1.100	42
Subscale 2 – “What are the ways that mind mapping was helpful?”			
5 Mind maps increase engagement in class.	4.26	0.928	48
6 Mind maps helped me identify gaps in my understanding.	4.38	0.721	50
7 Mind maps helped my teacher to see what I did not understand.	4.29	0.937	46
8 Making mind maps helped me to communicate with my peers about the topic.	4.29	0.879	49
9 Talking to my peers about the topic helped my understanding.	4.38	0.914	50
10 Mind maps helped me to revise.	4.02	1.084	44

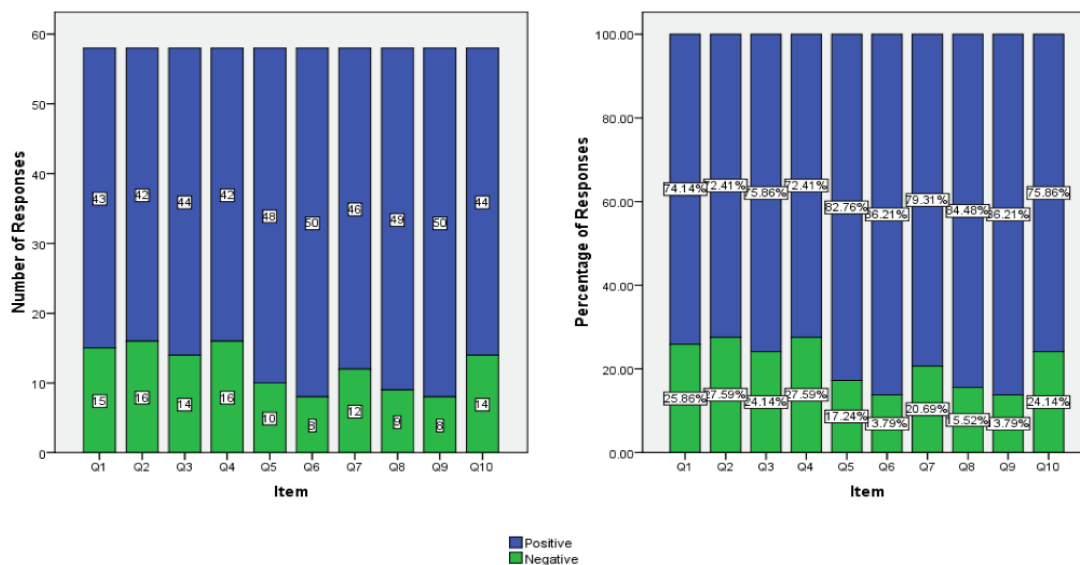


Figure 5. Stacked bar charts showing the distribution of positive and negative responses.

In order to assess whether the questionnaire differentiated between classes, comparisons were made between the overall mean summative scores after classifying by gender. This was done

by using the Mann-Whitney U test- the non-parametric analogue to the independent samples *t*-test. This test was employed based on the result of performing a Shapiro-Wilk test, which assessed whether the assumption of normality was upheld. Based on the results of the Shapiro-Wilk test ($p < .05$), it was concluded that the data for each grouping did not follow a normal distribution. Subsequently, the Mann-Whitney test was performed to assess whether the overall mean summative rank scores for males and females were equal. For each grouping, Table 4 provides summary statistics for both the summative scores and their related ranks. Based on the result for the Mann-Whitney test ($p > .05$), it was concluded that no differences existed between the scores for the two groupings.

Table 3. Shapiro-Wilk Test

Gender	Statistic	<i>df</i>	<i>p</i> -value
Male	.871	28	.003
Female	.912	30	.017

Table 4. Mann-Whitney U Test

Gender	N	Mean Score	Standard Deviation	Mean Rank	Sum of Ranks	Mann-Whitney U Statistic	<i>p</i> -value
Male	28	42.46	7.219	30.77	861.50	384.500	.579
Female	30	41.47	7.347	28.32	849.50		

Exploratory factor analysis was conducted on each subscale as well as the overall scale. Subscale 1 (4 items) was unidimensional whilst subscale 2 (6 items) was 2-dimensional. This was confirmed with the results for the entire instrument (10 items) being 3-dimensional. Table 5 shows the initial eigenvalues and the variance accounted for by the components for each scale.

Table 5. Initial Eigenvalues and Variances for Components

Component	Total	% of Variance	Cumulative %
Subscale 1			
1	3.042	76.039	76.039
2	.431	10.772	86.811
3	.306	7.658	94.470
4	.221	5.530	100.000
Subscale 2			
1	3.465	57.747	57.747
2	1.150	19.169	76.916
3	.505	8.420	85.336
4	.437	7.276	92.611
5	.324	5.394	98.006
6	.120	1.994	100.000
Overall Scale			
1	5.577	55.766	55.766
2	1.316	13.160	68.927
3	1.003	10.033	78.959
4	.538	5.381	84.341
5	.468	4.683	89.023
6	.349	3.491	92.515
7	.254	2.540	95.055
8	.241	2.406	97.461
9	.154	1.538	98.999
10	.100	1.001	100.000

Based on Kaiser's rule of thumb, we retain components with eigenvalues greater than or equal to 1 as this accounts for the most variance in the data. The scree plots in Figure 6 corroborate this where the portion beyond the "elbow" of the plot corresponds to factors that contribute very little variance (Suhr, 2006).

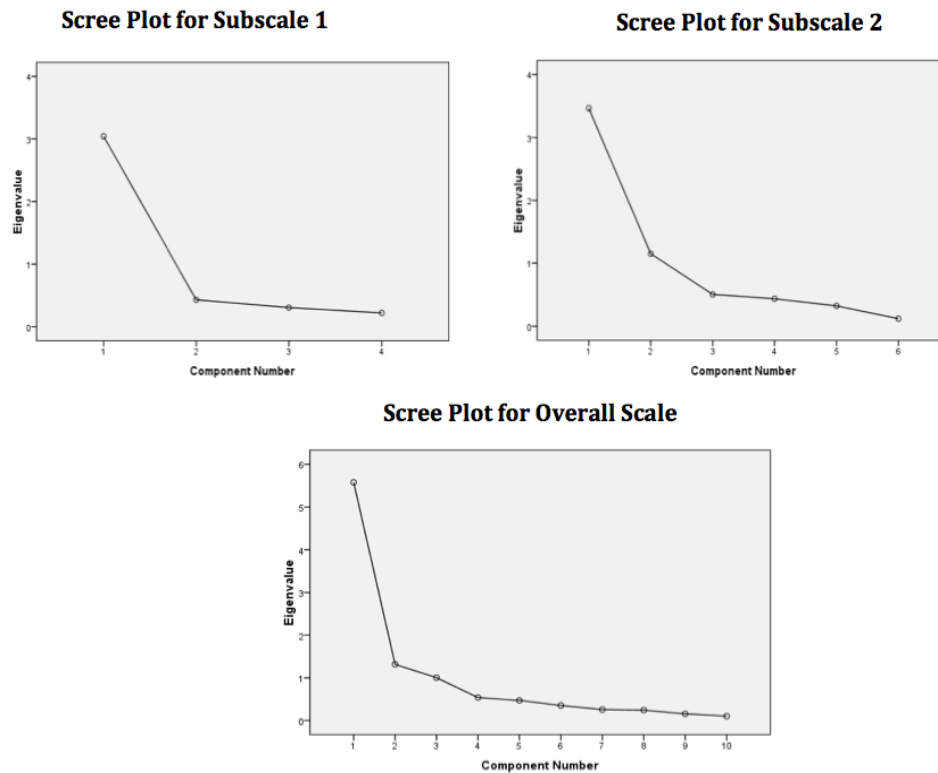


Figure 6. Scree Plots for dataset

Table 6 provides the factor loadings for each item of the overall scale after performing a *Varimax* rotation that facilitates ease of interpretation about the three retained factors. Loadings greater than or equal to 0.5 for each factor are underlined.

Table 6. Matrix of Factor Loadings after Varimax Rotation

		Component		
		1	2	3
1	Mind maps are useful.	.474	<u>.645</u>	.407
2	Mind maps are easy to create.	.256	<u>.828</u>	.208
3	Mind maps are fun to create.	.114	<u>.876</u>	.197
4	Mind maps make Science easier.	<u>.673</u>	<u>.630</u>	.141
5	Mind maps increase engagement in class.	<u>.714</u>	.264	.284
6	Mind maps helped me to identify gaps in my understanding.	<u>.776</u>	.096	.289
7	Mind maps helped my teacher to see what I did not understand.	.327	.326	<u>.663</u>
8	Making mind maps helped me to communicate with my peers about the topic.	.184	.198	<u>.919</u>
9	Talking to my peers about the topic helped my understanding.	.157	.156	<u>.910</u>
10	Mind maps helped me to revise.	<u>.867</u>	.219	.074

The 10-item section of the instrument demonstrated excellent internal reliability that was supported by each subscale demonstrating good internal reliability. Analysis of the overall mean summative scores after classification by gender showed that perceptions concerning the usefulness of mind mapping were the same for both male and female classes.

Subscale 1, the scale concerned with measuring the behaviour regarding whether mind mapping was helpful demonstrated good construct validity as it remained unidimensional. Whilst subscale 2 emerged as a 2-dimensional construct, which suggests that another behaviour, other than that concerning the ways in which mind mapping was helpful, was being measured. This was supported by the factor loadings for the overall scale in the rotated matrix. Table 7 postulates the questions concerning behaviours that the 3-dimensional construct could be addressing. Thus, the responses to the items would support answers to the proposed questions. Consequently the perceptions of mind mapping based on these 3 different components could be determined.

Table 7. Proposed Factors

Factor 1 – “Does mind mapping help to achieve the class objectives?”

Mind maps make Science easier.

Mind maps increase engagement in class.

Mind maps helped me to identify gaps in my understanding.

Mind maps helped me to revise.

Factor 2 – “Does mind mapping enhance the learning opportunities?”

Mind maps are useful.

Mind maps are easy to create.

Mind maps are fun to create.

Factor 3 – “Does mind mapping improve communication in the teaching/learning exchange?”

Making mind maps helped me to communicate with my peers about the topic.

Talking to my peers about the topic helped my understanding.

Mind maps helped my teacher to see what I did not understand.

Open-ended questions to gather feedback on what were some perceived disadvantages of using such a teaching intervention saw students reporting very few; Three (3) students stated that; “maps were a waste of time”, and one (1) said, “mapping did not help me”. It should be noted that these responses all came from male students who were already pursuing their major and were doing this course to meet their graduation requirements. None of the female students cited any disadvantages. Two (2) respondents thought the class time was too short for creative and comprehensive maps and six (6) of them would have preferred if the mappings were done exclusively with a technology based method. Other comments made mention of the fact that creating the mind maps helped them to stay focused during the activity and the group setting helped them to bounce ideas off each other. In doing this they were able to listen to, critique and build on each other’s scientific mental models. Two different students shared their feelings via unsolicited emails, “...thank you for applying the mind map idea on our class it really helped me and I hope it help(ed) my colleagues”, and “...Thank you so much for this idea I feel so organise(d) and the plan (is now) (im)print(ed) in my mind. Now I want (to) do the exercise.”

Limitations to the study include the following:

- Selection bias. Selection bias may have been introduced since the sample selected was done using a non-probability sampling method which may not make the findings of the study generalizable but only applicable to the specific population under investigation (Higginbottom, 2004).
- Inadequate Likert items. In order to ensure that exploratory factor analysis is robust, it has been recommended that each construct overarch a minimum of 3 items (Cunningham-Myrie et al., 2009). Whilst this minimum was met for the second subscale, refinement of the subscale by increasing the number of Likert items would have better encapsulated the 2-dimensional nature and improved the psychometric properties.
- Bias due to acquiescent response set (ARS). Since all the items measured on the Likert scale were positive statements, there was no control for the bias that may have been introduced based on the tendency to be in agreement with statements of opinion regardless of the item content (Cunningham-Myrie et al., 2009). The implications of this bias could also be amplified as the statements were written in English which is not the native language for the participants.

Conclusion

Our preliminary study shows evidence that suggests that the use of mind maps to teach science content may have significant implications in language learning environments. The brevity and ease of note taking, the reduction of cognitive load, and the ability to communicate knowledge without “filler” words was particularly useful to our students. Our findings are in tandem with those of other researchers who have had similar experiences, albeit sometimes teaching in different content areas (Budd, 2004; Dhindsa & Anderson, 2011; Eppler, 2006; Evrekli et al., 2009; Willis & Miertschin, 2006). Johnstone and Selepeng (2001) suggest that chunking, which is facilitated by mind maps, helps in main idea selection and relation of ideas, reduces the amount of information for processing and so increases the capacity of the mental working memory, which creates more space for critical thinking.

Another complementary aspect of using mind maps in our classes was the freedom of individual expression and creativity that was afforded to the students, which we believe was instrumental in stimulating students’ interest and hence increased engagement. This was evident in the variety of styles, the use of colour and even icons inserted in the mind maps. This is another feature that is useful in teaching Emirati students, who are by nature artistic and creative. This helps students to feel relaxed, creating a fertile environment for learning to take place. It also allowed for diverse learning styles and creativity within the classroom (Eppler, 2006).

The study also shows that mind maps provide a quick way to highlight student misconceptions and knowledge gaps. This satisfies a need of Arabic ELLs previously identified by Jewels and Albon (2012). Our investigation indicates that students are responsive to the technique, become engaged in the material and enjoy learning when able to discuss and organize their thoughts externally along with their peers (Budd, 2004).

The technique requires that instructors invest time initially in teaching students how to make mind maps. This can be done through teacher demonstration using prior topics. This initial investment can be completed in just a few lessons but the resulting rewards are great. Practitioners may find that incorporating mind maps in their classrooms not only facilitates individual learner needs, but also provide a vital tool for easy, prompt and effective formative assessment.

Future Work

In the next stage of this study we will be assigning both experimental and control groups to quantify the impact of using mind maps on students' academic attainment. Additionally we would like to explore the use of electronic devices to construct mind maps in contrast with paper and pencil methods. Whereas our students are digital natives and are accustomed to and love using mobile technology for its ease and versatility, recent studies have shown that the physical act of drawing using paper and pencil can add value to the learning experience and increase information retention, understanding and performance on exam (Ainsworth, Prain, & Tytler, 2011). Another area for exploration would involve investigating whether the quality of the mind maps created would predict students' performance (Ainsworth et al., 2011). The justification for this is that higher quality mind maps would be produced by students who engage in deeper processing of the content material and would therefore generate superior cognitive representations (Mason, Lowe, & Tornatora, 2013). It is further believed that the level of cognitive representation has a correlation to the understanding achieved in the content area (Ozuru, Dempsey, & McNamara, 2009).

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Appendix

Appendix 1. Example of the rubric used to formatively assess mind maps on the Enhanced Greenhouse Effect.

Key Points to be covered	General Rubric				
Names of greenhouse gases specified.	Essential concepts all shown.		Most concepts and relationships shown correctly.		Essential concepts left out.
Relationship between gases and radiation illustrated.	Important relationships correctly portrayed.		Some aspects left out.		Relationships not correctly portrayed.
Greenhouse gases shown to trap and hold IR radiation	No conceptual errors or evidence of misunderstanding		Minor conceptual errors or misunderstandings		Major conceptual errors or misunderstandings
Effects of global warming itemized.	All major effects discussed shown correctly portrayed.		Most major effects discussed shown correctly portrayed.		Essential effects of global warming not shown.
Methods of control and prevention mentioned.	No conceptual errors or evidence of misunderstanding		Minor conceptual errors or misunderstandings.		Major conceptual errors or misunderstandings.
Detail and presentation	Map is detailed and clearly drawn and labelled.		Map lacks some detail or not clearly drawn or labelled.		Map lacks detail or is illegible. Map is difficult to interpret.

Rubric adapted from (Johnson & Reynolds, 2005).

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