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The Effectiveness of Graphic Organizers in Fostering the Learning of Chemical Bonding in Chemistry

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Graphic Organizers are visual and graphic display that illustrates the correlations between facts, terms, and ideas with a learning task. Integrating Graphic Organizers can enhance the efficiency of the teacher's delivery of lessons and students' learning. However, no study had been conducted in using graphic organizers in the process of teaching and learning. Therefore, this explanatory mixed-method study aimed to investigate the effectiveness of Graphic Organizers in teaching Chemical Bonding to grade nine (n=98) students in Samtse Dzongkhag, Bhutan. The study's main objective was to compare the academic achievement of the control group (n=53) and experimental group (n=45) and also to investigate students' and teachers' (n=6) perceptions of using Graphic Organizers in teaching and learning Chemistry over four weeks. Learning achievement tests (pre-test and post-test), semi structured interviews, and survey questionnaires were used to collect the quantitative data and qualitative data. The independent sample t-test analysis of the post-test scores revealed a statistically significant difference between the control group and the experimental group with a mean difference value of 1.17 (p=0.017), indicating that the use of Graphic Organizers improved the students' learning achievement which was also reflected in the qualitative data gathered through interview and survey questionnaire. As a result, this study strongly suggests the use of graphic Organizers as a teaching and learning tool to improve students' academic performance in Chemistry.

Keywords: graphic organizers, academic performance, chemistry, dual coding theory, cognitive load theory

INTRODUCTION

Rabgay (2018) has suggested a shift in the pedagogical trend from teacher-centered teaching to learner-centered teaching to improve the quality of education. Considering the drawbacks of the traditional lecture-oriented teaching strategy, the Ministry of Education of Bhutan organized a weeklong workshop on transformative pedagogy involving all the teachers across the country in 2016. The training was on the adoption of Dr. Spencer Kagan's cooperative learning structures, active learning strategies, and modules based on brain-based learning, multiple and emotional intelligence, and transformative assessments to introduction educational need of the nation and to equip all levels of teachers with the concepts of student-centered learning, Knowledge-based learning, assessment-based learning and community-based learning (Wangdi, 2016). The training package included teaching skills and strategies of the 21st century to equip teachers with adequate knowledge and skills to improve their classroom lesson delivery and enhance student learning. Also, the program was

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aimed to enable teachers to transform their teaching practice from teacher-centered to learner-centered teaching for effective learning.

Despite the Ministry's initiatives and efforts on the 21st century transformative pedagogy, students' performance in Chemistry in Bhutan has been consistently lowest among the Science subjects for the past four consecutive years (2016 – 2019) except in 2020, with average scores below average 50.0%. Moreover, it was also observed that students' performance in Chemistry was significantly lower in-grade tests and home examinations (Chogyel & Wangdi, 2021).

Traditional teacher-centered teaching approaches such as lecture, question/answer, teacher demonstration, project, and grade experiment methods are standard methods used by Chemistry teachers in developing countries (Chabari, 2018). Ineffective teaching approaches that are teacher-centered contribute to low achievement in Chemistry (Muraya & Kimamo, 2011). Moreover, traditional classroom teaching practices still widely exist in Bhutanese classroom teaching, thus attributing to rote learning (Gyamtso & Maxwell, 2012). Rote learning, according to Ross et al. (2020) is mastering a content through repetitions over a long period of time without understanding the actual meaning of it. Rote learning as a learning method is found ineffective for meaningful learning (Tan, 2010). Therefore, there is a need to explore other effective methods of instruction over the traditional approach to enhance students understanding of concepts in the subject and improve students' performance in the issue.

The integration of Graphic Organizers in Bhutanese schools would be one of such innovative and interactive teaching approaches. Graphic Organizers are innovative pedagogical tools that provide facts and concepts in their organized frame (Nakıboğlu & Nakiboğlu, 2021). Integrating Graphic Organizers in chemistry lessons can enhance the efficiency of the teacher's delivery and students' learning. Graphic Organizers exist in various forms such as concept maps, story maps, advance diagrams, semantic maps, or concept diagrams. Numerous educational and cognitive psychology researchers recommend that Graphic Organizers be implemented in the classroom across all subjects since implementing graphic representations in classroom teaching enhances students' understanding of the content (Horton et al., 1990). However, no prior study has been carried out to determine the effect of Graphic Organizers in teaching Chemistry in Bhutan. Therefore, this study was undertaken to devise a new approach that can be used to address the issues. This study also attempts to investigate the effectiveness of Graphic Organisers in teaching chemical bond.

Literature Review

What is a Graphic Organiser?

According to Almulla and Alamri (2021), Graphic Organizers are visual and graphic display that illustrates the correlations between facts, terms, and ideas with a learning task. Graphic Organizers are also pedagogical tools that provide a holistic representation of facts and concepts and their relationships within an organized frame (Dye, 2000). It helps students organize and structure the information about the idea in a logical sequence of instructional materials (Wangzom, 2019). According to Torres et al. (2014), Graphic Organizers appear to be popular among modern schools. It is used as a major teaching approach and as the accepted teaching strategy in the classroom. Graphic Organizers have been applied across the subjects, and research-based applications have demonstrated their classroom utilization in Science, Social Studies, Language, Arts, and Mathematics. It also involves mapping cause and effect, comparing and contrasting concepts, note-taking, organizing problems and solutions, and integrating information with central concepts or themes (Hall et al., 2002 as cited in Torres et al.,2014).

Types of Graphic Organiser

Graphic Organizers are visual and graphic display that depicts the relationship between facts and terms or ideas within learning. As of now, thirteen different patterns of Graphic Organizers have been reported: Descriptive or Thematic Map, Network Tree, Spider Map, Problem and Solution Map, Problem-Solution outline, Sequential Episodic Map, Fishbone Map, Comparative and Contrastive Map, Compare – Contrast Matrix, Continuum Scale Series of events chain, Cycle Map and Human Interaction Outline (Hall & Strangman, 2008).

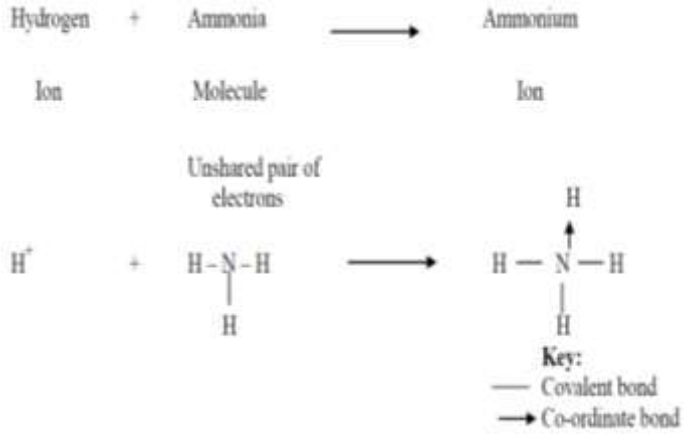
Types of Graphic Organizers applicable to teaching Chemical Bonding

Four basic categories of Graphic Organizers that can be incorporated with teaching Chemical Bonding are:

Cyclical organizers (Cycle Map) that can be used to make students understand the sequence circle of types of chemical bonds. It represents a cyclic flow of events, with the last cycling back to the first event, representing continuous events. The use of cyclical organizers assists students in making connections and visualizing the relationships between broad concepts or topics. Cyclical organizers serve as a place to visualize connections and organize information for visual learners, students who struggle to organize their thoughts or students who struggle to see relationships between concepts.

The conceptual map (Comparative and Contrastive Map) shows the relationships and organization between the concepts. It shows the organization of the relationship between concepts and helps to compare concept attributes to see considerable differences and similarities between simple molecular structure and giant molecular structure. It helps students to compare and contrast ideas according to their features (Wang et al., 2020). According to Ciullo et al. (2015), compare and contrast Graphic Organizers can be used more favorably in teaching science and social science subjects as they can provide students with a clear idea of abstract concepts.

Sequential organizers (series of events) show the sequence of ideas on a specific topic or subtopic.



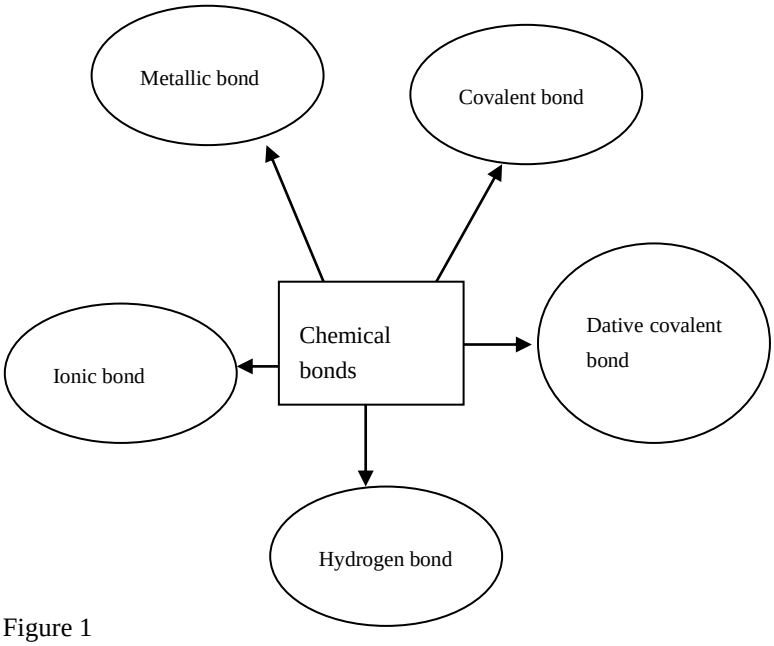


Figure 1
Example of sequential organiser

Figure 1 is an example of a sequential Graphic Organizer showing the formation of a coordinate bond in ammonium ions. Sequential organizers are used to show the sequence of events in a process. The formation of ammonium ions shows the arrangement of the ideas where the unshared pair of electrons from the ammonia molecule are shared with the hydrogen ion, which lacks electrons to form a duplet structure with each atom finally attaining a stable state. According to Saindra and Mutiarani (2019), Sequence Organizers help students to see the sequential relationship between events in a text and help students identify cause-and-effect relationships.

Hierarchical organizers (network tree) show the relationships between concepts hierarchically from more specific to general concepts and ideas. According to Lusk (2014), Hierarchical Organizers are useful in concept-based teaching where students are allowed to see the concept at the top as well as the topics and the facts at a glance.

Theory of Learning Achievement

Teachers' perception of the impacts of Graphic Organizers

Graphic Organizers enable teachers to easily explain relationships between content and sub-content, help learners acquire visual information more efficiently, and enhance interactive lessons across all subjects (Chabari, 2018). Sari et al. (2019) studied the perceptions of teachers in using the Graphic Organizer in the classroom and found that majority of the participants (teachers) revealed that the use of Graphic Organizer in classroom teaching can enhance recall, retention, and summarization of the main concept. In a study by Lynn and Miranda (2011), they found that the results of the teacher questionnaire which described their perception were overwhelmingly positive for the interventions' effectiveness and ease of implementation where students were found to be motivated to learn. Similarly, Praveen and Rajan (2013) asserted that Graphic Organizers provide teachers with tools with which they can sharpen learners' critical and creative thinking by developing their ability to comprehend and understand the concept.

Moreover, numerous educational and cognitive psychology researchers also believed that Graphic Organizers simplified the teaching and learning process since implementing Graphic Organizer in classroom teaching enhanced students' understanding of the content (Horton et al., 1990). Similarly, many researchers Chabari (2018); Hall et al. (2008); Wangzom (2019) also found similar perspectives being shared by teachers and educators.

Students' perceptions of the impacts of Graphic Organizers

Those students who used Graphic Organizers can understand the whole concept and demonstrate proficiency in problem-solving, critical thinking, and applying knowledge in real-life situations (Sing, 2015). For instance, in a study by Torres et al (2014), students opined that Graphic Organizers improve learning by fostering information recall and enhancing students' understanding of complex concepts in Chemistry. Moreover, students also expressed that Graphic Organizers helped them organize new concepts to their existing knowledge, summarise the concept and present the information in sequence (Cala, 2019). Additionally, according to Hawk (1986), Graphic Organizers were also believed by the students as a tool to improve their academic achievements. Similarly, Wangzom (2019) mentioned that students viewed Graphic Organizers as one learning pedagogies to improve students' academic performance. Moreover, Graphic Organizers assists students in activating prior knowledge, gaining insight into text structure, identifying and connecting the main ideas resulting in better recall and retention of information (Fatimayin, 2017).Therefore, students expressed that lesson can be organised in the grade environment for meaningful learning by considering how learners learn (Burdina et al., 2019) whereby allowing students to think and monitor their learning by organising new concepts based on existing knowledge.

METHOD

Research Design

This study followed an explanatory sequential method, which allowed the researcher to collect and analyze quantitative data first and build on the qualitative result to explain in more detail with qualitative data. The blending of quantitative and qualitative approaches provides more comprehensive answers to the research questions. It addresses the limitation of a single approach (Downward, 2023). The Quantitative components include the Chemical Bonding Concept Test (CBCT), Students Opinion Survey Questionnaire (SOSQ), and Chemistry Teacher Questionnaire (CTQ) built on five points Likert scale. Qualitative components included the collection of data through semi-structured interviews with the students and the teachers. Quantitative and qualitative data were collected concurrently in one phase. That data was analyzed separately and compared. So, qualitative data was used to validate the finding of the quantitative data.

Hence, the concurrent triangulation design was used in this study to collect data at one phase and analyze quantitative and qualitative data separately.

Sampling Technique

A total of 98 grade nine students were selected for this study following a convenience sampling from one of the High schools in Samtse Dzongkhag. Moreover, six students were selected using simple random sampling for a semi-structured interview to collect the qualitative data. Students were selected based on their performance in their post-test result. In addition, six teachers (3 males & 3 females) were chosen for perspective study on using graphic organizers.

The Intervention in Experimental Group(EG) and Control Group(CG)

The experimental group was taught Chemical Bonding with the help of Graphic Organizers for a week. In the second week, students were asked to develop Graphic Organizers based on the concept given in the text and asked to present them to the whole grade. The treatment in the experimental

group will indicate the effectiveness of Graphic Organizers to teach Chemical Bonding. Moreover, the differences between scores of pre-tests and post-test of EG and CG showed the Graphic Organizers' significance in enhancing learning outcomes in Chemistry.

Finally, a semi-structured interview was conducted to collect data from students and six teachers to compare the effectiveness and perception of Graphic Organizers.

Control Group (n=45) is an essential part of many research designs, allowing the researcher to minimize the effect of all variables except the independent variable. The control group is also taught the same topic in the classroom for the same duration. They were introduced to the topic based on a textbook activity.

Data Analysis

Quantitative data collected was analyzed using the Statistical Package for Social Science (SPSS) version 22. Similarly, the qualitative data were transcribed and analyzed based on Creswell's thematic coding technique (Creswell, 2014).

FINDINGS AND DISCUSSION

This chapter presents the key findings of the study in the following subheadings.

Students' Perception toward Graphic Organizers Approach

Analysis of quantitative data indicated that students have an overall positive perception of Graphic Organizers to learn Chemical Bonding in this study. This finding validated and accepted research sub-question 2. Mean (m), standard deviations (SD), and degree of perception were analyzed to examine students' perceptions of Graphic Organizers.

Students Interest

To measure their interest in Graphic Organizers, students were asked to rate their agreement with response statements on a 5-point Likert-type item, with the categories ranging from 1 (strongly disagree) to 5 (strongly agree). The descriptive analysis results on the students' factor (i.e., interest) indicated the overall mean value of 4.19 with the standard deviation of 0.87 (Table 1), indicating that the students possessed a high level of interest in using Graphic Organizers to learn Chemical Bonding. This interpretation was made by referring to the (Gyeltshen & Rai, 2023), as shown in table 1.

Table 1
The interest of students towards learning chemical bonding using graphic organizers

Item No	Items	N	Mean	SD	Level of perception
1	I enjoy participating in the lessons using Graphic Organizers	45	4.20	0.757	High
2	I had fun working in a group to develop Graphic Organizers.	45	4.24	1.048	High
3	The learning activities on Chemical Bonding were interesting, while lessons were delivered through Graphic Organizers.	45	4.29	0.843	High
4	I look forward to using Graphic Organizers in learning Chemical Bonding	45	4.22	0.795	High
5	I am a student who gets encouraged when the teacher uses Graphic Organizers.	45	4.02	0.988	High
6	The learning is fun when the lesson is taught using Graphic Organizers.	45	4.22	0.795	High
7	Graphic Organizers can help to increase my achievement in Chemistry.	45	4.13	0.894	High
	Overall	45	4.19	0.87	High

[1.00- 1.50: Lowest, 1.51-2.50: Low, 2.51-3.50: Moderate, 3.51-4.50: High, 4.51-5.00: Highest (Adapted from Gyeltshen & Rai, 2023, p.1]

Similarly, most students in their interview expressed that Graphic Organizers enhanced their interest in learning Chemical Bonding. For instance, S6 expressed that:

It makes me interested in learning since it extends to another level from what we already have since grade one, and it has a different way of teaching, so it makes me interested in lessons.

Further, most of the students also opined that Graphic Organizers helped them connect the ideas to learn abstract concepts. For example, S2 expressed that:

I liked to be taught using Graphic Organizers because it connects the new concepts to what we already know.

Further echoed by S2 that:

Because while learning using Graphic Organizers, it's like we are playing with similar topics, which makes me inspired to learn.

Moreover, linear regression analysis with interest as the independent variable and the students' Chemical Bonding concept test scores as the dependent variable showed that the amount of variance explained by students' interest in the Chemical Bonding concept test in the experimental group was significantly different from zero, R^2 =0.171. Consequently, as much as 17.1% of the (R^2) among the CBCT of the experimental group can be attributed to the student's interest in learning Chemical Bonding with the help of Graphic Organizers. The significant value (p=0.005) is less than 0.05, indicating that the regression model statistically predicts the outcome variables. The findings showed that the students' interest in learning Chemical Bonding with Graphic Organizers was strongly related to their performance on the Chemical Bonding Concept Test. As per the qualitative data, students found the lessons interesting and satisfying. Such kind of learning was better than the traditional method as it required students to use their skills to collect relevant information and to understand the relationships between different ideas and organize and synthesize information. This finding was supported by Wangzom (2019), who reported that the use of Graphic Organizers demonstrated positive emotions such as enjoyment, hope, and pride in learning.

Understanding of the students

The following analyses were performed on the scale indices of students' understanding of the concept (Chemical Bonding): descriptive Analysis, correlational Analysis, and linear regression analysis. Table 2 presents the mean, standard deviation, and degree of perception of experimental group participants' understanding of Graphic Organizers in learning Chemical Bonding.

Table 2
The level of understanding of students towards learning chemical bonding using graphic organizers

Item No	Items	N	Mean	SD	Level of perception
1	I can relate the concept of Chemical Bonding to a real-life situation.	45	3.78	1.042	High
2	The lessons promoted my understanding of Chemical Bonding	45	3.93	0.889	High
3	The Graphic Organizers help me to understand the concept of Chemical Bonding better than other strategies.	45	4.04	0.824	High
	Overall	45	3.92	0.92	High

Table 2 shows the average mean (M=3.92) and standard deviation (SD=0.92) of participants' confidence in learning Chemical Bonding using GOs. This indicates a high perception level of learners' understanding of learning Chemical Bonding using Graphic Organizers. The interpretation of the result was based on the Brown model, as shown in table 2.

Similarly, linear regression analysis with students' understanding as the independent variable and the students' Chemical Bonding concept test scores as the dependent variable showed that the amount of variance explained by the understanding of students' Chemical Bonding concept post-test in the experimental group was slightly different from zero, R^2 =0.124. Consequently, as much as 12.4% of the (R^2) among the Chemical Bonding concept test of the experimental group can be attributed to the student's understanding of learning Chemical Bonding with the help of Graphic Organizers. The significant value (p=0.018) is less than 0.05, indicating that, overall, the regression model statistically cannot predict the outcome variables. The findings showed that the students' understanding of Chemical Bonding with Graphic Organizers was moderately related to their performance on the Chemical Bonding concept test. The students reported that Graphic Organizers helped simplify and enhance theie understanding of the concept. Sing (2015) supported this finding, stating that students who use Graphic Organizers could understand the whole concepts and demonstrate proficiency in problem-solving, critical thinking, and applying knowledge in real-life situations. Further, Graphic Organizers improve information recall and enhance students' understanding of complex concepts in Chemistry(Torres et al. 2014).

Analysis of the achievement test between CG and EG.

Table 3 compares pre-test scores between CG and EG before the intervention, and it was observed that there were not many differences in their scores. It indicated that the learning abilities of learners were taken into consideration.

Table 3
Independent sample T-Test of Pre-test between Groups

	Group	N	Mean	Mean Difference	SD	Sig (2 Tailed)
Pre-test	CG	53	6.13		1.981	
	EG	45	6.09	0.08	2.382	0.098

After four weeks intervention, a post test scores were analyzed for significance difference.

Table 4
Independent sample T-Test of Post-test between groups

	Group	N	Mean	Mean Difference	SD	Sig (2 Tailed)
Post-test	CG	53	8.47	1.17	1.928	0.017
	EG	45	9.64		2.838	

The result of an independent sample t-test subjected to post-test data analysis indicated a statistically significant difference (p=0.017) between CG and EG with the mean difference value of 1.17, indicating the effectiveness of Graphic Organizers over the traditional method (Table 4). The use of Graphic Organizers in learning Chemistry significantly affected students' achievement in tests because it enhanced their understanding of the concept of Chemistry and memory retention. Many researchers have highlighted how Graphic Organizers in the grade improve learning achievement. This finding was consistent with that of the finding of Ayverdi et al., (2014); and Saynay., (2014) who claimed that Graphic Organizers enhance student comprehension power of new learning and improve recall of information. Further, Suarez (2011), stated that Graphic Organizers promote higher-order thinking.

CONCLUSION

Students' perception of learning Chemical Bonding when taught using Graphic Organizers. The findings of this study indicated Students perceived Graphic Organizers to be an effective teaching strategy because they increased their interest and understanding, felt easy and satisfied, and improved their thinking skills.

Teachers' perception of using the Graphic Organizers in teaching Chemical Bonding. The study revealed teachers viewed Graphic Organizers as an effective teaching strategy since they allowed students to understand better and retain concepts for a more extended period, increased students' interests, fostered students' creativity, and assisted teachers and students in revision.

The effectiveness of Graphic Organizers as an instructional strategy for learning and understanding Chemical Bonding. Based on data analysis of the groups' post-test scores (EG and CG), the EG students outperformed the CG students, confirming the effectiveness of Graphic Organizers in this study. These findings ultimately proved that Graphic Organizers are an effective teaching tool for increasing students' learning as measured by test scores and increasing their interest, understanding, feeling, satisfaction, and thinking skills.

RECOMMENDATION

This research revealed that Graphic Organizers were an efficient teaching pedagogy for enhancing students' motivation and learning in Chemistry. The success of Graphic Organizers is based on the teacher's ability to use Graphic Organizers. The report also recommends that officials such as principals, Dzongkhag education officers, and the teacher professional support division undertake professional development programs on the use of Graphic Organizers for in-service teachers and provide adequate resources for applying this method.

The study revealed that the teachers viewed Graphic Organizers as an effective teaching strategy since they allowed students to understand better and retain concepts for a more extended period, increased students' interests, fostered students' creativity, and assisted teachers and students in revision. Chemistry teachers are recommended to incorporate various Graphic Organizers in teaching Chemistry to boost students' learning motivation and raise performance in the disciplines.

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