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ORIGINAL ARTICLE

Students' Performance, Satisfaction, and Experiences in Graphic Organizer Integrated Online Instruction of Astronomy

Jennifer A. Endiape[1]*, Jamaica Fayette V. Lopez[1], Zenerica T. Lastimosa[1], Charie Ann V. Gecain[1], Nheljay Mae C. Herbieto[1], Joje Mar P. Sanchez[2,3], Marchee T. Picardal[2]

[1]Bachelor of Secondary Science Education Department, College of Teacher Education, Cebu Normal University, Philippines, [2]Science Education Department, College of Teacher Education, Cebu Normal University, Philippines, [3]Translational Research Division, Institute for Research in Innovative Instructional Delivery, Cebu Normal University, Philippines

***Corresponding Author:** jenniferendiape0@gmail.com

ABSTRACT

This quasi-experimental study determined Graphic Organizer Integrated Online Instruction's effectiveness in understanding astronomy concepts. Three groups of Secondary Science Education students from a state university in Central Visayas, Philippines, were exposed to text, both text and graphic organizers, and the latter only. Study findings revealed that students across the three groups obtained above-average performances and improved performance; these groups also showed no significant difference in the improved performance. Using graphic organizers yielded high retention and satisfaction among the students, as they were immersed in visual-verbal instruction, a valuable learning scaffold, and a fun experience. In conclusion, the use of Graphic Organizer Integrated Online Instruction was effective in improving student performance, retention, and learning experiences. Integrating these visual tools in online instruction is highly recommended for use at the undergraduate level in the new normal.

KEY WORDS: Astronomy; graphic organizers; online class

INTRODUCTION

The COVID-19 pandemic has put the quality of education at risk (Pokhrel and Chhetri, 2021). Regular face-to-face classes worldwide were suspended, and vast adjustments to supplement education in many countries, including the Philippines, were implemented. With this transition, self-directed learning has become a theme in education. Flexible learning is introduced and emphasized for the convenience of the students so that learning would not be disrupted. Despite challenges and difficulties, educational institutions uphold quality teaching and learning (Ferri et al., 2020). Various strategies were offered to deliver a flexible modality of learning. In the flexible learning modality, free digital learning materials are provided to the students. Printed learning modules are given to students with inadequate technological devices and internet connections. A combination of the strategies mentioned above is also utilized in the delivery of lessons.

Moreover, one of the other ways educators provide in the teaching-learning process is by integrating graphic organizers.

Graphic organizers are visual learning aids that assist in categorizing and articulating the students' thoughts (Torres et al., 2014; Roman et al., 2016; Nakiboglu, 2017; Ponce et al., 2018; Tandog and Bucayong, 2019). These enable the learners to formulate and establish information and communicate it effectively. Additionally, using graphic organizers improves the acquisition of data, recognition of knowledge, and development of positive emotions among students (Avila, 2020). In Biology and Physical Science classes, student's academic achievements and ability to organize concepts and visually relate them in solving processes have improved, respectively (Sakiyo and Waziri, 2015; Kaur and Kamini, 2018; Chukwu and Dike, 2019; Tandog and Bucayong, 2019; Avila, 2020). These studies prove how graphic organizers can create meaningful learning and improve students' performances. However, graphic organizers have yet to be explored in online learning settings. With this study, the researchers integrated graphic organizers into online classes called Graphic Organizer Integrated Online Instruction.

This study aimed to determine whether Graphic Organizer Integrated Online Instruction effectively teaches astronomy concepts among Secondary Science Education students. Specifically, the study (1) determined the entry and exit performances in astronomy in the control and experimental groups A and B; (2) compared these entry and exit performances as well as between control and experimental groups; (3) determined the level of retention and satisfaction toward the use of graphic organizers; and (4) unveiled the experiences of using graphic organizers in the online class. The critical study of Canlas (2013) noted that college students have alternative conceptions about selected astronomy topics and showed evidence that a wide gap exists in understanding the concepts. Therefore, graphic organizers may enrich educational institutions' and educators' knowledge and awareness of the competence of Secondary Science Education students in astronomy. The results are also significant because the students will discover their learning performances, guiding them to become successful life-long learners. Hence, the study aims to recognize graphic organizers as a practical learning scaffold.

Theoretical Framework

This study was anchored on the Schema Theory, stating that students learn new information by activating their prior knowledge or schema (Anderson, 1977). Mental models, known as schemas, represent knowledge about the world. As new knowledge is incorporated into the schema, the students are more likely to understand the new knowledge. This tenet is coherent with the use of graphic organizers in teaching. Using graphic organizers, they can more easily activate their pre-existing schemas and organize new information more straightforwardly to understand and remember.

Graphic organizers have been the subject in the read literature. Ropič and Aberšek (2012) used web graphic organizers to teach comprehension in a science textbook. They revealed that these organizers assisted students in finding essential concepts in the science text while they became competent in comparing new information with the prior ones. Knight et al. (2013) applied graphic organizers to systematic instruction for students with autism and intellectual disability. They revealed that they improved their vocabulary, comprehension, and understanding of concepts related to convection.

Moreover, Torres et al. (2014) found that graphic organizers can improve students learning in chemistry because these organizers help students better understand and remember concepts. Sakiyo and Waziri (2015) noted that concept mapping had improved students' biology achievement. Roman et al. (2016) revealed that students exposed to graphic organizers performed significantly better than those who did not, suggesting that these organizers help bridge inferences in science texts. Like the two studies mentioned earlier, Ponce et al. (2018) also found that interactive graphic organizers can provide a better understanding to students as these organizers assist students in visualizing and organizing information and connecting between different concepts.

Furthermore, Ayverdi et al. (2014) enumerated different graphic organizes that include fishbone, pyramid, cause-and-effect maps, spider webs, and future semantic analysis, and Nakiboglu (2017) suggested organizers, such as concept maps, T-charts, flow charts, and Venn diagrams. With the experimental group performing better than the control group, Nakiboglu (2017) and Kaur and Kamini (2018) noted that using these organizers lets students be more engaged in learning, leading to a better understanding of concepts. Tandog and Bucayong (2019) and Chukwu and Dike (2019) also had similar results, which were attributed to the confidence and active indulgence of the students in the graphic organizers, ultimately resulting in more profound mastery of content and retention. Similarly, the study of Avila (2020) also resulted in substantial improvement among experimental group students, highlighting the compelling nature of graphic organizers to enhance college student's comprehension and retention of science concepts.

MATERIALS AND METHODS

Research Design, Environment, and Participants

This empirical investigation utilized a quasi-experimental design, as the random assignment and practical constraints in administering randomized samples were not feasible (Campbell & Stanley, 1963; Grimshaw et al., 2020). The study employed the pre-test-post-test with control design, where entry and exit performances are determined for the control and experimental groups. A narrative inquiry was employed to explore the students' experiences while they learned using graphic organizer-oriented instruction. The study was conducted in a Teacher Education College in a state university in Central Visayas, Philippines. The education college is a center of excellence and training in education in the country, offers astronomy as a course for Secondary Science Education, and provides online classes during the pandemic.

The Secondary Science Education students participated in the study. A total of 63 students who voluntarily participated in the quasi-experimental investigation were divided into three groups. These groups were the control, experimental A, and experimental B, whose students were not exposed to graphic organizers, exposed to both words and graphic organizers, and exposed to graphic organizers, respectively, with 21 students each. With a $p < 0.05$, the three groups are comparable regarding their pre-test knowledge. In gathering the qualitative data, 10 participants were interviewed.

Research Instruments

Three online instruments were used in the study: (1) A pre-test/post-test/delayed post-test, (2) a 5-point Likert's scale questionnaire for the level of satisfaction, and (3) an interview guide. The pre-test/post-test/delayed post-test tool consists of the same multiple-choice items that include 40 items about topics on the Foundation Physics of Observational Astronomy. This tool is divided into four 10-item parts, namely light and electromagnetic radiation, spectroscopy and Doppler effect, optical telescopes, and radio- and space-based astronomy. Sample test items from the pre-test/post-test/delayed post-test are appended (Appendix A). The second instrument is the satisfaction level questionnaire comprising ten items with five-point scale from highly unsatisfactory (1) to highly satisfactory (2). The interview guide comprised three guide questions, and probing was based on these questions. Three astronomy experts validated the tools, and the former two were pilot tested on 30 non-participants. The reliability test values were 0.772 and 0.770 for the tests and questionnaire tools, respectively, indicating that the tools were reliable.

Data Gathering Procedure and Analysis

The researchers underwent appropriate research permissions, including Ethics Review (Certification no. 792/2021-04), dean approval, and participant informed consent. After securing these permissions, the pre-test was sent to the participants through Google Forms and returned within an hour to consider possible Internet constraints. The research pedagogies were then implemented in the research groups: The control group was exposed to words only, while the experimental Groups A and B were exposed to both words and graphic organizers and graphic organizers only, respectively. Sample instructional materials used for the control and experimental groups can be seen in Appendix B. These pedagogies were implemented after the lesson springboard and topic introduction before assessment, clarification, and lesson conclusion. After the month-long intervention, the post-test was given to them using Google Forms. After a month, the delayed post-test and satisfaction level questionnaire (only for experimental groups) were administered through the same platform. Then, ten students were randomly selected from the experimental groups for the recorded semi-structured interview conducted online through Google Meet.

The gathered data were stored and organized in Microsoft Excel and analyzed through the Statistical Package for the Social Sciences version 27. The entry, exit, and delayed test performances were analyzed using mean and standard deviation, while the satisfaction level was through percentages and weighted mean. The comparison between the said test performances and between the groups was analyzed through a *t*-test for paired samples and analysis of variance, respectively. The qualitative data derived from the interviews were analyzed through thematic analysis, following the six steps proposed by Braun and Clarke (2006). All data and videos were safeguarded and remained confidential, while names were kept anonymous.

RESULTS AND DISCUSSION

Performances of the Students in Astronomy

The entry and exit performances of Secondary Science Education students in topics on Observational Astronomy are presented in Table 1 below.

Table 1 shows that below-average entry performance was observed with the experimental group A and average entry performances for the control and experimental B groups. Above-average exit performances were observed for all groups. Introducing the topics on observational astronomy while implementing the respective pedagogies contributed to the enhanced performance of above-average ones.

The comparison between the entry and exit performances of the students in astronomy is presented in Table 2.

In Table 2, all groups had exit performances significantly different from their respective entry performances; hence, they had a significant mean improvement in astronomy as they were exposed to particular pedagogies. Using verbal representations (e.g., words), visual representations (e.g., graphic organizers), or both has improved the students' performances in observational astronomy. These representations enhance teaching and learning across science fields (Kambouri et al., 2016; Hansen and Richland, 2020; Sanchez, 2017), including astronomy (Chen et al., 2016; Galano et al., 2018).

The statistical comparison of the mean improvements between the three groups is shown in Table 3.

According to Table 3, statistical comparison among the mean gains of the three groups yielded no significant differences; hence, all groups had comparable mean improvements. In other words, using words, graphic organizers, or both used in the study have the same effect on the performance improvements of students in astronomy. Only words, such as in lectures, are still adequate and used in undergraduate astronomy instruction (LoPresto and Slater, 2016; Blanco et al., 2018). Similar to text, the use of graphic organizers is also an effective tool for better astronomy teaching, just like other physical and biological sciences (Sakiyo and Waziri, 2015; Kaur and Kamini, 2018; Chukwu and Dike, 2019; Tandog and Bucayong, 2019; Avila, 2020). The exact effectiveness of verbal and visual representations did not corroborate with most studies but with some, like the early findings of Simmons et al. (1988) revealing comparable results between graphic organizers and text-oriented discussion as well as the recent results on online science discussions (Castelyn and Mottart, 2012; Reed et al., 2018). This result may be because these representations are perspectives of the same astronomy concepts, adhering to the concept of multiple and tiered representations in science (Chen et al., 2016; Kambouri et al., 2016; Galano et al., 2018; Hansen and Richland, 2020; Sanchez, 2021). This statement means that there are many ways to represent scientific concepts, so teachers can use text and graphic organizers to understand astronomy concepts better.

Level of Retention of Students in Astronomy

The results of the delayed test performance and content retention are presented in Table 4.

Based on Table 4, all groups had above-average delayed test performances and high astronomy retention levels. However, only the experimental B group had more than 100% retention level across the different topics of observational astronomy. Both the use of verbal and visual representations leads to high

Table 1: Entry and exit performances of students in topics on observational astronomy

Group	Entry performance			Exit performance		
	Mean (SD)	t (ρ)	Description	Mean (SD)	t (ρ)	Description
Control	22.24 (5.80)	−1.391 (.179)	Average	31.00 (3.13)	10.247* (.000)	Above Ave.
Experimental A	21.24 (4.78)	−2.645* (.016)	Below Ave.	31.24 (5.21)	6.361* (.000)	Above Ave.
Experimental B	25.38 (6.61)	0.957 (.350)	Average	34.71 (2.72)	18.032* (.000)	Above Ave.

*Significant at α=0.05 as compared with the hypothetical mean (60% of the total score) retention. Still, the latter, in the form of graphic organizers, produces better retention levels coherent with the read literature on science teaching (Dexter et al., 2011; Ponce et al., 2018; Tandog and Bucayong, 2019; Christopher and Phillip, 2020).

The statistical comparison between the delayed test performances of the three groups is shown in Table 5.

Table 5 shows that the statistical comparison among the three groups showed a significant difference in the delated test performances. *Post hoc* comparison yielded a substantial difference between the control and experimental B groups, indicating that students learn more using visual formats than textual linear formats alone. This finding reiterates that graphic organizers could provide better retention levels to students in astronomy and other sciences (Dexter et al., 2011; Ponce et al., 2018; Tandog and Bucayong, 2019; Christopher and Phillip, 2020).

Level of Satisfaction towards the Use of Graphic Organizers in Astronomy

The level of satisfaction of the students toward the use of graphic organizers in astronomy is presented in Table 6.

Table 2: Comparison between entry and exit performances in astronomy

Group	Mean Gain	SD	t	ρ-value
Control	8.76	5.60	7.167*	0.000
Experimental A	10.00	4.98	9.202*	0.000
Experimental B	9.33	6.95	6.158*	0.000

*Significant at α=0.05

Table 3: Statistical comparison between the mean improvements in astronomy

Group	Sum of squares	Mean square	F	ρ-value
Control	16.13	8.06	0.232	0.794
Experimental A				
Experimental B				

Significant at α=0.05

As presented in Table 6, the students rated the use of graphic organizers as highly satisfactory across the identified indicators. This result means that they like and enjoy using such visual representations in their astronomy class online. The graphic organizers have assisted them in distinguishing ideas and reading and comprehension, as verbal or textual input is advantageous to their learning with graphics (Torres et al., 2014; Roman et al., 2016; Ponce et al., 2018; Nakiboglu, 2017; Tandog and Bucayong, 2019). Visual organizers can manage information because these tools can quickly understand new and complex concepts (Ropič and Aberšek, 2012; Knight et al., 2013; Ayverde et al., 2014). They prefer to use the organizers and recommend them to be used in their astronomy class as they find them useful in their class and beneficial to their learning (Torres et al., 2014; Fisher and Frey, 2018).

Experiences of the Students in the Use of Graphic Organizers in Online Astronomy Class

Through Braun and Clarke's (2006) analysis, three themes emerged, namely (1) visual-verbal instruction, (2) useful learning scaffold, and (3) fun experience.

Visual-verbal instruction

Students consider the use of graphic organizers as a visual-verbal instruction, as graphic organizers do not only support learning as visual displays, but these tools also communicate with the learner verbally. One participant said, *"I think I feel like I am no good in memorizing the concepts. Now that I use the graphic organizer to visualize and present concepts in a way that is easy to understand and memorize"* (P2, 16-20).

Aside from this, these visual representations have helped the students to summarize important points and add images that make them attractive and fun. Another participant can attest to this, *"Learning is made easy and fun and because some graphic organizers are nice to look at especially when the one who made it is like an artist like he/she formed the graphic organizer."* (P9, 49-53).

Graphic organizers are tools widely used in delivering instructions with their ability to integrate texts and visuals

Table 4: Delayed test performances of students in topics on observational astronomy

Group	Delayed test performance			Content retention		
	Mean (SD)	t (ρ)	Description	Difference	Retention %	Description
Control	31.38 (3.94)	46.510* (0.000)	Above Ave.	0.38	>100†	Very High
Experimental A	33.05 (4.34)	28.550* (0.000)	Above Ave.	1.81	>100†	Very High
Experimental B	35.52 (2.91)	29.498* (0.000)	Above Ave.	0.81	>100	Very High

*Significant at α=0.05 as compared with the hypothetical mean (60% of the total score); †not 100% retention across topics

Table 5: Statistical comparison between the delayed test performances in astronomy

Group	Sum of squares	Mean square	F	ρ	Significant *post hoc* (*p*)
Control	182.51	91.25	6.388*	0.003	Control versus Exp. B (0.002)
Experimental A					
Experimental B					

Significant at α=0.05

Table 6: Level of satisfaction with the use of graphic organizers in astronomy

Indicators	Mean	Description
Durability and easy use	4.69	H. Satisfactory
Enjoyment to use	4.60	H. Satisfactory
Help in distinguishing ideas	4.83	H. Satisfactory
Assistance in distinguishing ideas	4.57	H. Satisfactory
Assistance in reading/comprehension	4.55	H. Satisfactory
Use to manage new information	4.60	H. Satisfactory
Preference to use the graphic organizer	4.60	H. Satisfactory
Recommendation to use the graphic organizer	4.76	H. Satisfactory
Overall Satisfaction	4.52	H. Satisfactory

that show interrelationships between concepts, positively impacting science teaching (Sakiyo and Waziri, 2015; Kaur and Kamini, 2018; Chukwu and Dike, 2019; Tandog and Bucayong, 2019; Avila, 2020). Prior and existing knowledge helps students link information to new ideas, and teachers must facilitate the students in creating necessary connections for better learning (Ropič and Aberšek, 2012; Knight et al., 2013; Ayverde et al., 2014).

Useful learning scaffold

Graphic organizers helped the students quickly learn and consider these tools useful learning scaffolds in astronomical concepts. They serve as visual aids that organize information into parts and connect them to new ideas to guide students in shaping their thinking and learning. A participant mentioned that the organizers are informative scaffolds, *"I would describe my experiences helpful and informative because the graphic organizers help us in understanding the parts in our reference book."* (P3, 14-15).

As a scaffold, the visual tools guide them in learning the subject, *"The reference book is actually in pdf file where you can see the terms and concepts not arranged or organized. This finding is why graphic organizers are much easier because you are guided well for better and easy understanding."* (P5, 10-16). Due to this helpful scaffold, learning astronomy becomes efficient and productive, *"It makes me feel a bit more efficient, makes me feel more productive as I have learned more than just reading the book or module."* (P8, 52-54).

Learning in various forms, including graphic organizers, engages students' ability to acquire knowledge. Graphic organizers are valuable scaffolds as these tools visually represent ideas (Torres et al., 2014; Roman et al., 2016; Nakiboglu, 2017; Ponce et al., 2018; Tandog and Bucayong, 2019) and arrange information into chunks that guide students' deeper understanding (Ropič and Aberšek, 2012; Knight et al., 2013; Ayverde et al., 2014). This strategy makes concepts in astronomy easier to digest and links previous knowledge with new ones.

Fun experience

The students stated that they had learned the topics in astronomy in the easiest way possible with fun. They were delighted with the visualizations and refreshed their eyes with the pictorial integrations in the graphic organizers. These tools gave them a new experience, *"I felt that using graphic organizers, especially when we are currently online, is both a relief and refreshing way to enjoy Astronomy as a subject"* (P3, 22-28).

The visual symbols also provided them with flexible learning, *"I feel rather relaxed than overwhelmed because there is no wordy information in your screen"* (P10, 26-29). Finally, the students feel excitement when using the practical visual tools, *"It is exciting in a way that you will be able to gain more knowledge and easily understand the concept while getting a fun and new learning experience."* (P1, 27-31).

Using graphic organizers contribute to delight and fun that could impact excellent and positive attitudes toward astronomy and other sciences (Torres et al., 2014). They feel this experience as they have been aided in remembering and understanding concepts, leading to enhanced learning and expanded learning opportunities (Torres et al., 2014; Roman et al., 2016; Nakiboglu, 2017; Ponce et al., 2018; Tandog and Bucayong, 2019). This feeling makes the student's learning experiences relatable and relevant.

CONCLUSION

With the advent of online classes as the learning mode, astronomy teaching calls for effective and efficient learning experiences to derive maximum student learning. Using verbal and visual representations increased students' understanding of concepts, signifying the importance of multiple and tiered models in science instruction. Graphic organizers, as a form of visual representation, have the same effectiveness in improving learning but possess more excellent retention than text alone during an online class. Students' learning retention has been increased with graphic organizers due to the well-thought arrangement of concepts, embedded shapes, icons, and pictures, and the facilitative learning process.

Due to the advantages of using graphic organizers, the students are delighted with integrating graphic organizers into online instruction. The verbal-visual instruction, useful learning scaffold, and fun experience support the relatable and relevant learning experience despite the students' lack of physical face-to-face interaction. Deriving meaning from the overwhelming content of most school science texts and connecting the concepts logically and understandably have been the strength of graphic organizers in online learning. Hence, the graphic organizer-integrated online instruction used in the study is an effective visual-verbal instruction and efficient scaffolding for a better understanding of astronomy at the undergraduate level in the new normal.

The study is limited to the context where the authors are. With this, the researchers recommend future directions to more empirical studies about visual representations in science teaching, including astronomy. Replicating the present study is highly encouraged, increasing the sample size, content and competencies, and intervention duration to provide findings with teaching context.

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APPENDIX A

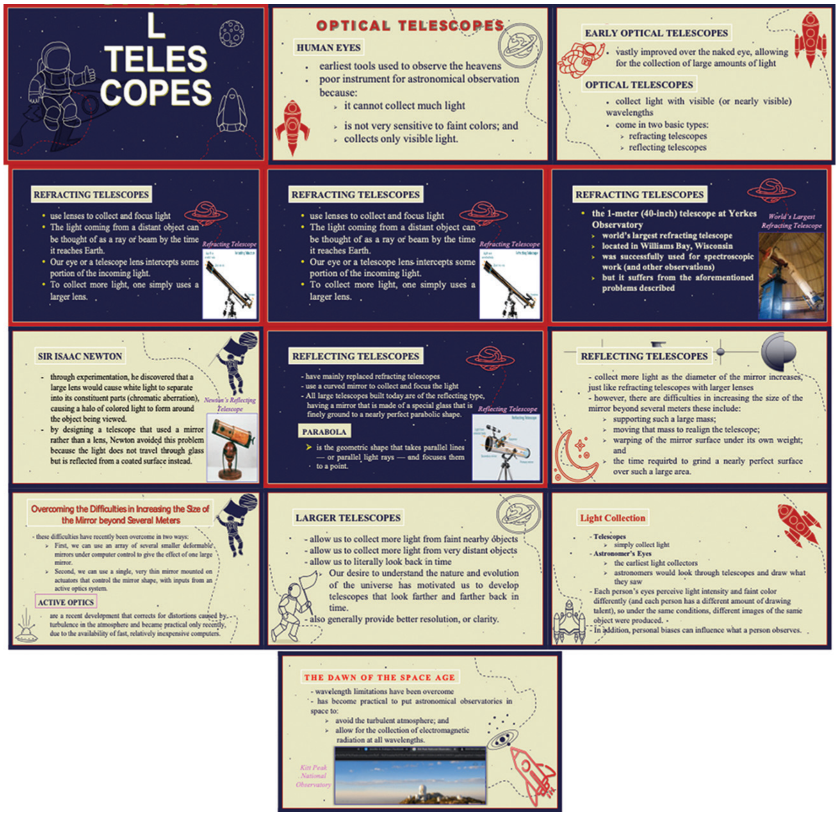
Sample Questions in the Pre-test/Post-test/Delayed Post-test

1. What is the dual nature of light?
   a. particle and a wave
   b. photons and radiation pressure
   c. wave and electromagnetic radiation
   d. photons and electromagnetic radiation
2. Which of the following statements is NOT a reason why human eyes are considered a poor instrument for astronomical observation?
   a. They only collect visible light.
   b. They cannot collect much light.
   c. They are not sensitive to faint colors.
   d. They allow the collection of large amounts of light.
3. Because large lenses are so heavy, they sag under their own weight, changing their__________and their_______.
   a. size, shape
   b. color, texture
   c. height, weight
   d. shape, focusing properties
4. The electromagnetic spectrum is arranged in:
   a. increasing wavelength, increasing frequency
   b. decreasing wavelength, increasing frequency
   c. increasing wavelength, decreasing frequency
   d. decreasing wavelength, decreasing frequency
5. It is produced by a large interstellar cloud consisting largely of hydrogen gas excited by extremely hot stars.
   a. darkline
   b. wavelengths
   c. emission/brightline
   d. continuous spectrum
6. Which of the following options accurately describes the statements?
   I. In the case of light, when a source is moving away, its light appears bluer than it actually is because the waves are lengthened.
   II. Objects approaching have their light waves shifted toward the spectrum's red (shorter-wavelength) end.
   a. Statements A and B are true.
   b. Statements A and B are false.
   c. Statement A is true, and Statement B is false.
   d. Statement A is false, and Statement B is true.
7. Evidence of events and processes provided by light is based from.
   a. intensity of wave, and its wavelength distribution
   b. intensity of light emitted, and its wave speed distribution
   c. intensity of light emitted, and its wavelength distribution
   d. intensity of the matter emitted, and its amplitude distribution
8. Why are the largest telescopes built on mountaintops, away from large cities?
   a. to avoid distractions and to have enough open space
   b. to get above most of the atmosphere and to get the best view of the night sky
   c. to avoid the noise of the major roadways and to be physically closer to objects in space
   d. to get away from as much of the turbulent atmosphere as possible and to reduce the effects

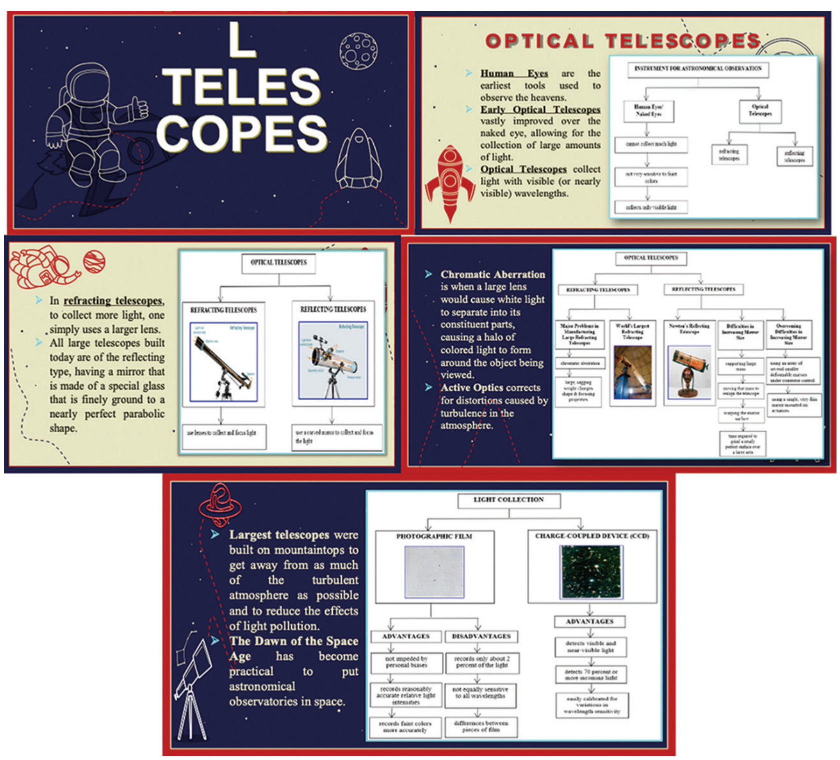
APPENDIX B

Sample Instructional Materials

Text Only (for the Control Group)



Both Text and Graphic Organizers (for the Experimental Group A)



Graphic Organizers Only (for Experimental Group B)