Effects of the Implementation of an Interactive Students' Notebook (ISN) on Students' Conceptual Understanding of Atomic Structure and Motivation Towards Science

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ABSTRACT

This study investigated the impact of an interactive student's notebook on Grade 8 Junior high school chemistry students' conceptual understanding of atomic structure and motivation toward science. Using a mixed-method sequential explanatory approach, a quasi-experimental non-equivalent groups design was employed, with pretest and posttest assessments, interviews, and questionnaires. The experimental group (using interactive notebooks) showed significantly higher conceptual understanding gains compared to the control group. The interactive notebook intervention also positively affected students' motivation, particularly intrinsic and career motivation. The study provides compelling evidence that incorporating Interactive Student Notebooks positively influences students' conceptual understanding of atomic structure and their motivation toward science. The use of ISNs facilitates higher levels of conceptual understanding, as reflected in the increased percentage of students achieving Level 4 proficiency in interpreting atomic theory and accurately representing atomic models. Moreover, ISNs contribute to higher levels of motivation, particularly in terms of career motivation and intrinsic motivation.

Keywords: *Interactive students' notebook; Conceptual understanding; Motivation; Conceptual evolution*

Introduction

In the Philippines, the science curriculum was developed to produce scientifically literate people who can use their knowledge to solve problems in their communities and make responsible decisions. (De La Cruz, 2022). The Philippines, however, performed the worst among all participating nations in the 2018 Program for International Student Assessment (PISA), which included Science as one of the disciplines evaluated. The results of the Philippines' inaugural participation in PISA have prepared the path for the Department of Education to propose more measures to address the country's poor academic performance and improve education quality (De La Cruz, 2022).

There is a gap in the current educational landscape regarding the use of effective note-taking strategies (Kiewra, et al., 2015), which can contribute to poor performance in science and other subjects. The Philippines' poor performance on the Programme for International Student Assessment (PISA) in 2018 highlights the need for research on strategies that can improve student performance in science and other subjects.

While researching other systems and strategies, the researcher came across a tool that the researcher thought could be used in connection with improving the students' conceptual understanding of different topics and areas of education and their motivation towards science. Social Studies Are Alive! curriculum written by the Teachers' Curriculum Institute (TCI) developed a tool known as the Interactive Students' Notebook (ISN).

Using interactive student notebooks for note-taking improved students' conceptual understanding on atomic structure and motivation towards science by providing a more engaging and interactive way for students to process and retain information.

The fact that students actively participate in their education shows that the ISN engages them. The notebooks serve as a portfolio of the students' learning, and they are urged to employ several intelligences (Bower & Lobdell, 2005).

With this, the study intended to contribute to the existing knowledge on the effect of Interactive students' notebooks on students' conceptual understanding of atomic structure and motivation towards science, specifically in the Philippine K to 12 science curricula. The study investigated the effects of interactive student notebooks on Grade 8 junior high school students' conceptual understanding of atomic structure and motivation toward science.

Methodology

Research Design

The study utilized a mixed method sequential explanatory in a quasi-experimental non-equivalent groups research design. This design investigates a research question or hypothesis using a combination of both quantitative and qualitative methods in a specific order. This type of research design is often used when there is a need to gather a more in-depth understanding of a phenomenon or to triangulate findings from different sources (American Psychological Association, 2020). The combination of quantitative and qualitative methods is used to reveal the significant relationship between variables. For quantitative methods, this study will utilize a non-equivalent control group quasi-experimental design. The researcher compares a group of subjects who have received the independent variable (the experimental group) to a group of subjects who have not (the control group). The quantitative data was obtained from a published test, it will serve as the pre-test and post-test. A post-in-depth personal interview with the aid of an observation log, audio tapes, and journal with possible probing/follow-up questions will be employed for qualitative design and triangulation, in which students' conceptual understanding and learning experiences will be gathered. This entailed one-on-one interviews with two representatives from each level (lowest, average, highest) of the participating class, using an interview schedule, and allowing free-flowing discussion. The analysis of the responses is through deductive approach thematic analysis. Deductive or theory-driven data analysis is a top-down approach in which the researcher codes and interprets the data based on a range of concepts, ideas, or subjects that they bring to the data (Braun & Clarke, 2012). The collection and analysis of quantitative data will be the first step in this approach, followed by the qualitative data acquired during the interviews and observations to explain or broaden the conclusions of the test results.

Research Locale

This study was conducted in one of the rural far-flung mountainous public schools in Victorias City, Negros Occidental, where cell phone/internet signal coverage was scarce. It took place in a Chemistry 8 Junior High School Science class, with the topic of Atomic Structure generally being discussed in the third quarter of the school year, as stated in the Science Curriculum guide of the Department of Education. Therefore, this research was implemented in the third quarter of the academic school year of 2022-2023.

Research Participants

In this study, one teacher was assigned to two sections of Grade 8 Chemistry. The teacher was a full-time teacher with five years' experience in teaching Chemistry 8. The implementing teacher was a graduate of a university also located in Victorias City, Negros Occidental, under the BSEd Biological Science Program, with a license to teach. The implementing teacher facilitated the class by implementing the interactive students' notebook on the experimental group, while the control group used the DepEd conventional module. The teacher was present in the classroom, particularly during exercises, and responded to students' inquiries while assisting them with any confusion or questions they had.

The participants in this study were grade 8 students enrolled in DepEd's Junior High School Chemistry 8 K-12 Curriculum from a rural far-flung mountainous public school in Victorias City, Negros Occidental, where cellphone/internet signal coverage was scarce. A total of two sections were used, one for the control group and one for the experimental group. The sample was collected through non-random convenient sampling. Only students who answered both the pre-test and post-test were considered as respondents/participants for the quantitative data. For the qualitative data, only selected participants from each level (lowest, average, highest) were interviewed to assess the evolution of their conceptual understanding.

Research Instrument

As mentioned in the previous sections, this research collected both quantitative and qualitative data. This section presents the detailed features of the different instruments that were used to collect the target data.

Z Fitriza and F Gazali's open-ended test for students' conceptual in atomic structure

Using open-ended questions, this study seeks to identify how students conceptualize the ideas of atomic structure. For this reason, chemistry high school students in Grade 8 will take a 7-item essay test. Where questions 1 and 2 have 5 levels (0 – lowest and 5 – highest), the question has 3 levels (0 – lowest and 3 – highest), and questions 4, 5, 6, 7 have 2 levels (0- lowest and 2- highest). An open-ended test covering the idea employed in the topic of atomic structure will be used to gather the data. The purpose of the open-ended conceptual test for students was to measure students' conceptual understanding of the concepts in Atomic Structure, find any alternative conceptions they might have, and determine how they might think about those concepts.

Science Motivation Questionnaire II (SMQ-II)

Science Motivation Questionnaire II by Shawn M. Glynn (2011) will be utilized to pre-and-post-assess students' motivation level in learning science. This can be applied in all areas of science, such as Biology, Chemistry, and Physics, and could interchangeably replace the word "Science" depending on the need of the research. This study adopted the science-specific version of SMQ II.

Data Gathering Procedure

The process of data gathering occurred during the 3rd quarter of the school year 2022-2023. Data gathering consisted of two phases: gathering the data and treating the data. By ethical standards, the researcher sought approval from the Division Superintendent, Principal, Parents, and Student participants of this study. The following section explains the process of data gathering in detail.

Ethical approval was obtained from relevant stakeholders - Division Superintendent, Principal, Parents, and Student participants. Phase I included pre-implementation, where materials were prepared, permissions obtained, and orientations conducted. Students were introduced to the Interactive Students' Notebook (ISN) on topics related to atomic structure after a pretest. Phase II, Implementation, spanned four weeks with pre/post-tests, interventions, and qualitative study selection. Post-implementation involved analyzing mean scores and frequency counts to determine learning gains and levels, respecting a two-week test gap. Phase II, Treatment of Data, outlined the procedure and statistical tools used for analysis.

Ethical Considerations

The study will strictly adhere to ethical guidelines by obtaining prior authorization from students, parents, teacher-implementer, and school for data collection. Informed Consent Forms will ensure transparency about risks, benefits, and processes, with participant confidentiality maintained throughout. The four-week intervention includes pre and post-tests and interviews, allowing withdrawal at any stage. The study ensures no known risks, emotional distress, or discrimination, and all collected data, stored securely, will be analyzed anonymously. After three years, the complete deletion of data, including test results and recordings, will be executed, reinforcing the study's commitment to ethical conduct, transparency, and confidentiality.

Results and Discussion

This section reveals the results of the implementation particularly the data collected in the pretest, posttest, and the interviews made. The data collected was used to determine whether there was sufficient evidence to answer the problem statements. Data were analyzed to determine the general distribution properties of the data. Forty-six (46) students from the experimental group and fifty- two (52) students responded to the pretest on Atomic Structure, a total of ninety-eight (98) students, but only thirty-three (33) students from the experimental group and twenty-six (26) students from the control group, a total of fifty-nine (59) students, accomplished both pretest and posttest. Thirty-nine (39) students were not included in the overall analysis of the study since they failed to take one of the tests, thus, a comparison of the progress before and after the intervention will not be possible. Deficiency of submission may stem from the reason that answering or complying with the test was not necessary or has no bearing on their grades or exam.

Initial Levels of Students' Conceptual Understanding of Atomic Structure

The *Open-Ended Test for Students' Conceptual Understanding of Atomic Structure*, developed by *Z Fitriza and F Gazali*, aims to assess students' comprehension of atomic structure concepts using open-ended questions. The test consisted of seven items and was administered to gather data on students' understanding of the topic. However, due to time constraints and other school curricular activities, the teacher-implementer was unable to cover topics addressed in questions 4 to 7. Therefore, the test was reduced to three items. The first two questions had five levels of proficiency, with level 0 representing the lowest level of understanding and level 5 representing the highest. The third question had three levels of proficiency, with level 0 being the lowest and level 3 being the highest. The following are the results of the pre-, and post-tests given to the students during the conduct of the study.

Most participants in both the experimental and control groups lacked a solid understanding of the concepts. As shown in Figure 1, in terms of the definitions, approximately 81.82% of participants in the experimental group and 80.77% in the control group were unsure or had misconceptions about atoms based on different theories. Only a small portion of participants (18.18% in the experimental group and 11.54% in the control group) were able to correctly mention the atom based on Dalton's atomic theory.

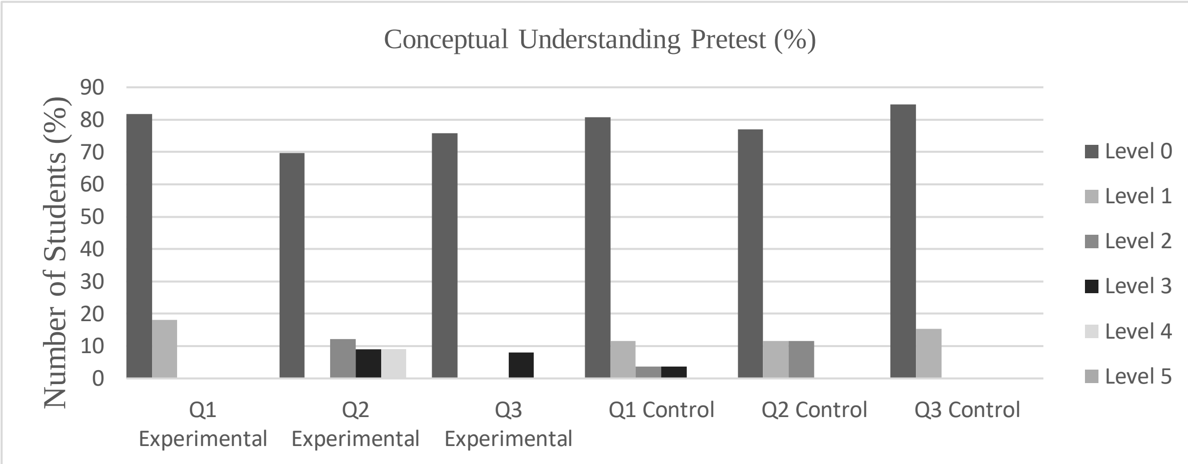

Figure 1. Initial levels of students' conceptual understanding of atomic structure

Initial levels of Students' Motivation toward Science

Collected data on the pretest on SMQ II was presented in Table 1. It showed the standard deviation, average scores, and levels of motivation for each factor: intrinsic motivation (IM), grade motivation (GM), self-determination (SD), career motivation (CM), and self-efficacy (SE). The highest score that the students could give is 4, while 0 is the least. Each factor contains 5 items. Thus, 20 points would be the total score for each factor and a total of 100 in general. The following are the results of the pre-tests given to the students during the conduct of the study.

Table 1. Descriptive statistics of pretest results on motivation levels of students

	Experimental			Control		
Factors	**Mean of Sums**	**SD**	**Level of Motivation**	**Mean of Sums**	**SD**	**Level of Motivation**
Grade Motivation (GM)	14.5	2.7	High	15.0	3.3	High
Career Motivation (CM)	14.6	2.9	High	13.8	3.2	High
Self-determination (SD)	13.4	3.2	High	14.2	3.1	High
Intrinsic Motivation (IM)	14.7	2.9	High	15.5	2.6	High
Self-efficacy (SE)	12.9	3.1	High	14.7	2.3	High
Overall	**70.1**	**11.1**	**High**	**73.2**	**11.6**	**High**

The means of 70.1 and 73.2 were considered high motivation which could be seen in the SMQ II pretest results of the experimental and control group.

Students' Conceptual Evolution

The researchers conducted interviews with students to collect their conceptual evolution during the intervention and support the gathered results on the quantitative data. Table 2 presents the students' cases and indicates the respective category they belong to.

Table 2. Students' cases in the experimental and control group

	Pretest Scores	Control group	Pretest Scores	Level	Description
P1	8	Student 7	8	High	Demonstrates a strong understanding of the concept
P2	7	Student 8	7	High	
P3	5	Student 9	4	Average	Shows moderate understanding with some room for improvement
P4	3	Student 10	2	Average	
P5	0	Student 11	0	Low	Struggles to grasp key concepts
P6	0	Student 12	0	Low	

In the study, the researcher opted to use deductive thematic analysis due to its suitability for the research objectives and the nature of the data. The choice of deductive thematic analysis allowed the researcher to apply predefined themes or codes to analyze the data systematically. By adopting a deductive approach, the aim was to examine the data through the lens of preexisting theories, concepts, or frameworks. This method facilitated an exploration of how well the data aligned with established theories or the testing of specific hypotheses. The utilization of deductive thematic analysis provided a structured and focused analysis, offering valuable insights into the predetermined themes or categories within the study. The themes considered in the study are the three types of conceptual evolution: conceptual change, conceptual development, and conceptual growth as shown in Table 3.

Table 3. Thematic analysis of students' responses about their conceptual understanding

Themes	Sample Illustrative Code
Conceptual Change	
Reframing	Altering the way, a concept is understood
Challenge	The concept is called into question
Revision	Updating or modifying an existing understanding of a concept
Conceptual Development	
Layering	Building upon an existing understanding of a concept by adding new information or insights
Conceptual Growth	
Skill development	Acquiring new abilities or proficiencies

Students' Conceptual Evolution in the Experimental Group

Some statements of the students in the experimental group or those who were taught using the interactive students' notebook might show hints of what made the students perform better. For instance, one student's response indicates a change in their understanding of atomic theory after learning about different models of the atom. This represents a conceptual change, specifically a reframing of their understanding.

> *"Before learning about the different models of atoms, I had a limited understanding of atomic theory... I learned about the different theories that scientists proposed about the structure of atoms, and how these theories evolved. For example, Dalton proposed the first modern atomic theory, which stated that all matter is made up of atoms that are indivisible and have specific properties. Thomson proposed the plum pudding model, which suggested that atoms were made up of a positively charged substance with negatively charged electrons embedded in it. Rutherford's gold foil experiment showed that atoms have a small, dense nucleus at their center, which is surrounded by electrons. Bohr's model of the atom proposed that electrons orbit the nucleus in specific energy levels."*

The student's statement highlights the impact of learning about the various theories proposed by scientists regarding the structure of atoms. By gaining knowledge about these different models, the student's perspective on atomic theory underwent a significant transformation. The term "reframing" suggests that the student's previous mental framework or conceptual schema surrounding atomic theory was adjusted or modified based on the new information they acquired. Another subtheme of conceptual change that is evident in the analysis is the process of revision, which involves updating or modifying existing understandings of a concept based on new insights or evidence.

> *"…at first, I thought that an atom was just a circle but now I know what an atom looks like according to Bohr's atomic model."*

The student undergoes a significant shift in their initial understanding of atoms, moving away from the misconception of atoms as circles towards a revised and more accurate perception. The process of revision, as described by the student, aligns with the notion that individuals modify their conceptual frameworks based on new insights or evidence (Davis, 2018). Another student mentioned that seeing a picture of an atom in the notebook changed their perception of its appearance. This indicates that visual representations can play a crucial role in facilitating conceptual development (Gilbert, 2010, as cited in Palis et al., 2014).

> *"…it changed my understanding of atoms. Before, I had no idea what they looked like. When we were given the notebook, we opened it and found a picture of an atom. That's when I learned about the parts of an atom. Before, I only knew about electrons and protons. But because of the notebook, I learned that there is also a neutron inside the nucleus."*

The student's response primarily focuses on the process of acquiring new knowledge and adding it to their existing understanding of atoms. They describe how their understanding changed when they were given a notebook with a picture of an atom, which introduced them to the parts of an atom. This process aligns with the subtheme of "Layering" within the "Conceptual Development" theme.

Student 3 also showed the same theme (Conceptual development) and subtheme (Layering). He indicated that the notebook made studying easier.

> *"Before, ... I knew that atoms had protons, neutrons, and electrons, ... But the short descriptions helped me understand these things better. Now I know that sub-atomic particles are the tiny things that make up atoms, and ions are atoms or molecules that have a charge because they lost or gained electrons…"*

Another theme that emerges in the analysis is "Conceptual growth" with the specific sub-theme of "skill development". Conceptual growth is an ongoing and continuous process that occurs through learning, practice, and reflection (Smith, 2020). It allows individuals to develop a deeper and more sophisticated understanding of a concept, enabling effective application in various contexts and problem-solving situations (Anderson, 2019).

> *"I like the mnemonic APE MAN (**A**tomic No.=No. of **P**rotons=No. of **E**lectrons, **M**ass no. – **A**tomic no.=No. of **N**eutrons) because it is easy to remember and use, and there are practice exercises provided. If I forget something, I can simply go back to the APE MAN section and answer the questions again."*

Mnemonic techniques, such as acronyms, rhymes, and visual aids, are effective for improving memory and recall during notetaking (Schneider, 2014). Notably, mnemonic training can significantly improve learning and retention of academic material, particularly for students with lower prior knowledge or those at risk of poor learning outcomes (Dunlosky et al., 2017).

However, it is vital to note that conceptual change can be challenging and uncomfortable, especially when it involves questioning deeply held beliefs or correcting misconceptions (Taber, 2013; Vosniadou & Brewer, 2019). One student expressed feeling challenged by new questions that had not been discussed in class.

> *"To be honest, sir, I found the notebook difficult at first. I couldn't understand some of the topics and it was hard to comprehend…"*

Students' Conceptual Evolution in the Control Group

Similarly, the researcher also conducted interviews with the students in the control group to gather information on their conceptual evolution during the intervention (conventional module of DepEd) and to support the quantitative data collected. Thus, the data provided by the student interviews and post-test results on atomic structure and models show both positive and negative trends.

Student 7 of the control group mentioned that their initial perception of atoms as simple, spherical entities drastically changed after learning about the different components of an atom, such as protons, neutrons, and electrons, and their respective charges and locations within the atom.

> *"Before, I thought that atoms were just tiny balls that make up everything. But now, I learned that atoms have different parts like protons, neutrons, and electrons."*

This observation underscores the significance of addressing misconceptions and delivering accurate information in fostering a precise and comprehensive understanding of atomic structure among students (Smith et al., 2018). The use of interactive activities played a crucial role in shaping students' comprehension of atomic structure. For instance, a student highlighted how the activity involving the use of magnets to model electron movement around the nucleus enhanced their visualization of the dynamic nature of atoms.

> *"The activity that affected the change was the one where we used magnets to model how electrons move around the nucleus of an atom. It helped me visualize how atoms are not static but dynamic."*

These responses fall under the theme "Conceptual change" specifically in the subtheme "reframing".

While some students demonstrated improvement in their understanding of the topic, others did not show much change in their ideas about atomic structure and models.

"...my ideas about the topic did not change much. I already knew that atoms have subatomic particles like protons, neutrons, and electrons…"

Moreover, some students expressed indifference or disinterest in the topic of atomic structure overall. They viewed atoms as boring and irrelevant to their lives.

"…I don't care about their subatomic particles or their models or their properties…"

These responses highlight the need to establish connections between the subject matter and real-world applications, demonstrating the practical implications and relevance of atomic structure in various fields such as medicine, energy, and materials science (Thompson et al., 2020). Furthermore, these findings emphasize the importance of enhancing student motivation to foster a deeper understanding and interest in learning about atomic structure.

Comparison of Thematic Analysis Results for Experimental and Control Group

The study aimed to investigate students' conceptual evolution during the intervention and support the quantitative data collected. Thematic analysis was employed using pre-existing frameworks, focusing on three types of conceptual evolution: conceptual change, conceptual development, and conceptual growth.

When comparing the thematic analysis results of the experimental and control groups, both groups showed instances of conceptual change and development, and only the experimental group showed conceptual growth. In the experimental group, students experienced reframing, layering, revision, challenge, and skill development indicating shifts in their understanding of atomic theory through exposure to diverse perspectives and the incorporation of new information. The use of interactive activities and visual representations played a crucial role in facilitating their conceptual evolution.

The findings from the thematic analysis emphasize the significance of employing interactive learning tools, such as the Interactive Science Notebook (ISN), to facilitate conceptual change and deepen students' understanding of atomic structure. Integrating interactive activities, formative assessments, and a supportive classroom culture are crucial in fostering students' conceptual evolution. Additionally, addressing misconceptions, delivering accurate information, and establishing real-world connections are essential for developing a comprehensive understanding of atomic structure. The use of the ISN in the experimental group proved to be an effective strategy in promoting conceptual understanding and motivation of the subject matter.

Final levels of Students' Conceptual Understanding of Atomic Structure

As shown in Figure 2, the experimental group showed improvements in their responses, particularly in terms of accurately identifying the sub-particles of an atom and drawing atomic models. However, it is important to note that both groups still displayed areas of misconception and incomplete knowledge.

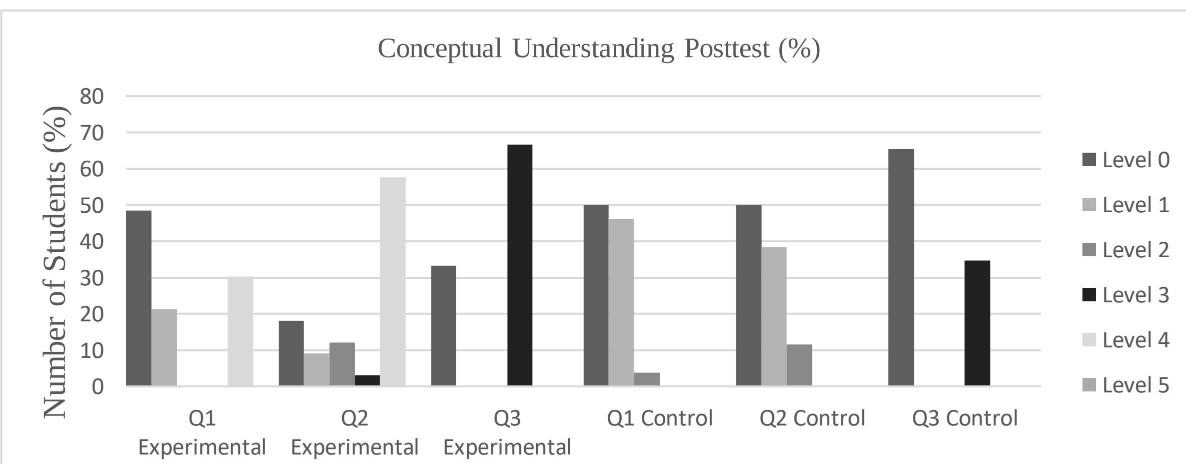

Figure 2. Final levels of conceptual understanding in the experimental and control group

Final levels of Students' Motivation toward Science

The data analysis revealed that both the experimental and control groups displayed high levels of motivation for each of the various parameters examined (see Table 4). Nonetheless, the experimental group outperformed the control group with a mean total of 76.8 as opposed to 72.8 for the control group. The experimental group, which received the interactive students' notebook intervention, generally had slightly greater mean sums of motivation than the control group, which exhibited high levels of motivation as well.

Table 4. Descriptive statistics of post-test results on motivation levels of students

	Experimental			Control		
Factors	**Mean of Sums**	**SD**	**Level of Motivation**	**Mean of Sums**	**SD**	**Level of Motivation**
Grade Motivation (GM)	15.5	3.1	High	14.8	3.3	High
Career Motivation (CM)	16.0	3.4	High	13.8	3.5	High
Self-determination (SD)	14.6	3.2	High	14.5	3.2	High
Intrinsic Motivation (IM)	16.4	2.6	High	15.2	2.7	High
Self-efficacy (SE)	13.7	3.3	High	14.5	2.2	High
Overall	**76.8**	**12.6**	**High**	**72.8**	**11.5**	**High**

Difference in Conceptual Understanding Before and After the Intervention

As shown in Table 5, the median difference in scores between the two groups was notable, with the experimental group showing a substantially higher median difference (53.13) compared to the control group (9.38). The Wilcoxon test, a non-parametric test for independent groups, supported these findings, as the test statistic for the experimental group (496) exceeded that of the control group (162). Both groups demonstrated p-values below the common significance threshold of 0.05, indicating statistical significance.

Table 5. Test of difference in conceptual understanding before and after the intervention

Group	Median difference	Wilcoxon	p-value
Control	9.38	162	<0.05
Experimental	53.13	496	<0.05

Difference in Conceptual Understanding Between Groups

As shown in Table 6, during the pre-test, the median difference in the average grades between the experimental and control groups was -3.13%. The obtained p-value was greater than the predefined significance level of 5%. Based on these results, there was insufficient evidence to suggest that the pre-test scores of the experimental group were higher than those of the control group. This indicates that, before the intervention, there was no significant difference in the conceptual understanding between the two groups.

However, following the implementation of the intervention, the post-test results revealed a notable change. The median difference in the average grades between the experimental and control groups was 40.63%. The corresponding p-value was less than the significance level of 5%. This provided sufficient evidence to reject the null hypothesis and accept the alternative hypothesis, indicating that the median grade of the experimental group was higher than that of the control group.

The results suggest that the implementation of the ISN intervention had a positive impact on the student's conceptual understanding of atomic structure. It is worth noting, however, that the experimental group's lack of understanding of the wave mechanical model may be attributed to the possibility that the teacher-implementer did not cover this topic during the intervention. While this limitation must be taken into account, the overall results highlight the potential effectiveness of the ISN approach in enhancing students' comprehension of complex scientific concepts.

Table 6. Test of difference in conceptual understanding between groups

	Median difference (%)	Mann-Whitney	p-value
Pretest	-3.13	162	>0.05
Posttest	40.63	496	<0.05

Difference in Motivation Before and After the Intervention

Table 7 reveals significant differences in the motivation levels of students within the control group. The results showed that there was no significant difference in grade motivation levels before and after the intervention, with a mean difference of -0.27 and a p-value of 0.78. Similarly, there was no significant difference in self-determination, intrinsic motivation, and self-efficacy levels before and after the intervention, with mean differences of 0.23, -0.31, and -0.12, respectively, and p-values of 0.69, 0.72, and 0.78, respectively. However, the study found that there was an increase in career motivation and self-determination levels after the intervention; with a mean difference of 0.039 and 0.23, but it is still deemed insignificant because both factors have a p-value greater than 0.05.

Table 7. Test of difference in motivation before and after the intervention for the control group

	Test	Mean	Levels	SD	Mean diff	P-value	Mann-Whitney (U-test)	Effect Size (RBC)
Grade Motivation (GM)	Pretest Posttest	15.0 14.8	High High	3.3 3.3	-0.27	0.78	353.5	-0.046
Career Motivation (CM)	Pretest Posttest	13.8 13.8	High High	3.2 3.5	0.039	0.82	325.5	0.037
Self-determination (SD)/	Pretest Posttest	14.2 14.5	High High	3.1 3.2	0.23	0.69	316.0	0.06
Intrinsic Motivation (IM)	Pretest Posttest	15.5 15.2	High High	2.6 2.8	-0.31	0.72	358.0	-0.06
Self-efficacy (SE)	Pretest Posttest	14.7 14.5	High High	2.3 2.2	-0.12	0.78	353.5	-0.05
Overall	**Pretest** **Posttest**	**73.2** **72.8**	**High** **High**	**11.6** **11.5**	**-0.42**	**0.92**	**344.0**	**-0.017**

For the experimental group, as shown in Table 8, even though all five components improved, three factors produced p-values greater than 0.05, which implied it was not significant. Difference on test results on self-determination (p=0.088), grade motivation (p=0.12), and self-efficacy (p=0.42) factors were regarded non-significant. Hence, student motivation levels on these factors have not changed noticeably because of the students' interactive notebook.

Table 8. Test of difference in motivation before and after the intervention for the experimental group

	Test	Mean	Levels	SD	Mean diff	P-value	Mann-Whitney (U-test)	Effect Size (RBC)
Grade Motivation (GM)	Pretest Posttest	14.5 15.5	High High	2.7 3.1	1.0	0.120	422.5	0.22
Career Motivation (CM)	Pretest Posttest	14.6 16.0	High High	2.9 3.4	2.6	0.036	381.5	0.30
Self-determination (SD)/	Pretest Posttest	13.4 15.2	High High	3.2 4.2	1.8	0.088	412.0	0.24
Intrinsic Motivation (IM)	Pretest Posttest	14.7 16.4	High Highest	2.96 2.6	1.7	0.015	356.5	0.35
Self-efficacy (SE)	Pretest Posttest	12.9 13.8	High High	3.1 3.3	0.9	0.420	481.0	0.12
Overall	**Pretest** **Posttest**	**70.1** **76.8**	**High** **High**	**11.1** **12.6**	**6.7**	**0.03**	**374.0**	**0.31**

On the other hand, intrinsic motivation and career motivation results were deemed to have a significant difference, with a p-value of 0.015 and 0.036 respectively. Intrinsic motivation increased by 1.7 which changed its level from "high" to "highest". An intrinsically motivated person performs tasks that they find interesting and enjoyable (Deci et al., 1999; Amabile & Pratt, 2016; Fischer et al., 2019). Furthermore, Ryan & Deci (2017) described that intrinsically motivated students are more likely to engage in learning activities for the inherent satisfaction they derive from the process, leading to higher levels of academic achievement and overall well-being. This characteristic was found true in the current study based on the learning experiences of the students. Student 3 asserted "*It's enjoyable, sir. It's challenging to learn the concepts in the subatomic particles. I study the periodic table and engage in activities in the notebook, and I truly study and learn from them. I love the feeling of being able to relate to what the teacher is talking about".* Students claimed that interactive student' notebooks helped them understand the lesson better since they could write notes while the teacher was discussing the lesson. Student 2 quoted *"It helped me understand parts of the lessons that I found difficult to understand before. With the help of the notebook, we were able to understand more. It was especially helpful because we could write notes while our teacher was discussing the lesson."*

The results show a significant improvement in motivation scores from the pretest to the posttest. The significant increase in motivation as a result of the interactive students' notebook is highlighted by the mean difference of 6.70 points between the pretest and posttest scores. The idea that the interactive students' notebook intervention played a key part in the noticed increase in motivation is further supported by the p-value of 0.03 and the computed effect size of 0.31.

Difference in Motivation Between Groups

During the Pre-test phase, before any intervention was implemented, no significant difference was observed between the experimental and control groups. The median difference was found to be -5.0% across both groups. The associated statistic is 30.0, and the high p-value of greater than 0.05 suggests no significant evidence to reject the null hypothesis. Therefore, any observed difference is likely due to chance.

Table 9. Test of difference in motivation between groups

	Median difference (%)	Mann-Whitney	p-value
Pretest	-5.0	30.0	>0.05
Posttest	5.0	436	<0.05

Moving to the Post-test phase, after implementing the interactive student notebook intervention in the experimental group and providing the conventional DepEd module to the control group, a significant difference was observed. The median difference between the experimental and control groups was found to be 5.0%. The associated statistic is 436.0, and the low p-value of less than 0.05 indicates strong evidence to reject the null hypothesis. Thus, the observed difference is unlikely to be due to chance and suggests a significant effect or relationship resulting from the interactive student notebook intervention compared to the conventional DepEd module.

Conclusions

The study aimed to investigate the impact of an Interactive Science Notebook (ISN) intervention on students' conceptual understanding and motivation in the context of atomic structure. The results revealed that both the experimental and control groups initially exhibited limited understanding of atomic theories and models, with notable misconceptions. The implementation of the ISN intervention led to significant improvements in the experimental group's conceptual understanding, as evidenced by thematic analysis and post-test scores. Thematic analysis highlighted conceptual change, development, and growth in the experimental group, emphasizing the importance of interactive tools and visual aids in the learning process. Moreover, the ISN intervention positively influenced students' motivation, particularly intrinsic motivation and career motivation, as indicated by post-test results and qualitative responses.

Comparatively, the control group also demonstrated instances of conceptual change, but with a wider range of responses, including limited improvement and disinterest in the topic. The study underscored the importance of addressing misconceptions, delivering accurate information, and establishing real-world connections to enhance student motivation and foster a comprehensive understanding of atomic structure.

Statistical analyses further supported the effectiveness of the ISN intervention, with significant differences in post-test scores and motivation levels between the experimental and control groups. The findings suggest that the ISN approach positively influenced students' conceptual understanding and motivation, highlighting its potential as an effective pedagogical tool in science education.

However, limitations, such as the possibility of incomplete coverage of topics and variations in teacher implementation, should be acknowledged. Despite these limitations, the overall results emphasize the promising impact of the ISN intervention in improving students' learning outcomes and motivation in the study of atomic structure.

Contributions of Authors

The authors confirm the equal contribution in each part of this work. All authors reviewed and approved the final version of this work.

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Conflict of Interests

All authors declare that they have no conflicts of interest

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