http://aif-doi.org/lnssh/010117

Chapter17: Raising the Achievement of Low Performing Students by Scaffolding Knowledge Integration in the Science Classroom

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Abstract: Reading is a cognitive exercise that promotes an understanding of scientific texts during high school physics lessons. Notably, science texts are linguistically and cognitively challenging, thus, students depend upon diverse scaffolds to comprehend the texts. Most low performing students lack the experience with scientific langauge and literary skills needed to face knowledge in physics. As such, the continuous training of teachers in administering knowledge is imperative to improve performance and achievement of learners in science classes. Thus, this capstone project investigates the impact of scaffolding knowledge intergration in high school students enrolled at Colonial high school in Orange County. Moreover, this project proves that non-invasive scaffolding is necessary to promote effective administration of learning instructions. Also, verbal participation of students in the class content elaborates on the acquisition of knowledge, and promotes both inferential and literal comprehension, and diverse opportunities for the learners to construct knowledge. Overall, scaffolding techniques are necessary components in knowledge intergration and help to increase the performance of high school science students.

1 Introduction

Within the science class context, i.e., problem-based and laboratory-related instructions, reading is the most frequently adopted activity in learning, which is employed to aid learners in becoming more interested in physics and understanding the phenomena behind diverse scientific processes. Besides, these texts offer learners an exceptional opportunity to learn scientific and academic language, which enables them to become robust participants in a society that rapidly advances in science. On the other hand, these texts also communicate the requirements for reflexive and critical readers. As such, students in high school are expected to integrate information and build their scientific knowledge not only from different laboratory activities but also from reading scientific texts. Consequently, this capstone project evaluates the implications of introducing scaffolding knowledge integration to raise the performance or achievement of students within the typical science classroom.

Reading, as any other epistemic activity, shares particular cognitive processes with scientific studies, e.g., elaboration of questions, hypothesis formulation, prediction, inference, classification, and observation. Furthermore, students can learn about various scientific studies and activities through reading comprehension. Besides, reading also helps students to interpret diverse modes adopted in scientific reasoning, deepen the development of different research processes and knowledge, and gain an in-depth understanding of the science discipline. Most importantly, reading gives learners access to knowledge on complicated processes in physics and offers teachers the ability to evaluate what their students have learned and understood throughout their entire operation.

For most high school students, physics textbooks are linguistically and conceptually sophisticated, which makes it difficult or challenging to incorporate class readings that benefit students through disciplinary material. Notably, the difficulty in reading, which causes poor performance upon evaluation, is partly caused by lacking prior knowledge and vocabulary to construct a mental representation of scientific facts. Different studies showcase that there is a more substantial effect between science reading comprehension

and prior knowledge in comparison to texts that are literary-narrative. Furthermore, the functions and language forms adopted in scientific books make them challenging for multiple students, which leads to low performance.

Most physics texts are conceptually dense. Moreover, they employ technical vocabulary in explaining abstract procedures through complicated and less familiar logical associations to the learners. In fact, they use a particular discursive organization of content, predominated by argumentations, and explanations that establish diverse scientific concepts beyond temporal orders. As such, learning to interpret expository science texts in contemporary classroom contexts demands teachers to offer explicit and specific patterns of support, which enables children to face the challenges in comprehending scientific content, leading to better performance.

In raising the achievement of low performing students in the science classroom, the practice of effective teaching must be characterized and documented. How efficiently reading is adopted in learning during science lessons will, therefore, be evaluated. Results from various standardized tests will be used, in this project, to characterize the performance of students in physics classes. As such, this projects focuses on the impact of cognitive scaffolding in increasing the levels of physics comprehension in a typical class context, which raises the performance of science scores. Also, this study will be guided by the following research questions:

1. How does scaffolding approaches to knowledge integration impact student comprehension of diverse learning material in science?
2. What is the role of reading in a science class? Are there differences in how effective science teachers adopt reading during science classes to foster better performance?
3. What are the attitudes of instructors and students on instructional approaches in learning, such as scaffolding knowledge intergration?
4. What efforts should be put in place in promoting an environment that fosters learning and teaching of physics concepts?
5. What levels of verbal participation, comprehension in reading, functions, and types of cognitive scaffolding are promoted by effective science teachers, thereby resulting in high-performance physics scores?

2 Literature Review

Scaffolding Reading Comprehension of Texts in Science

From a sociocultural model, the physics instructor is expected to play a vital role in the emotional, motivational, and cognitive scaffolding of learners in understanding texts based on scientific knowledge. Notably, the teacher is also expected to facilitate a deeper sense of reflexive learning amongst the students, leading them to have generated interest in diverse scientific phenomenon. Greater skills, with increased self-regulation and autonomy, eventually result in an improved performance after assessment. Notably, scaffolding robustly supports students in tackling problems and tasks in reading comprehension, which enables them to gain coherence in understanding scientific processes.

Moreover, the support from the science teacher is particularly important whenever students lack enhanced vocabulary (due to insufficiently developed disciplinary and academic language) and when their reading repertoire is limited. Most likely, such conditions result from less effective teaching, little schooling, and less literate families. If the science teacher is aware of the impact

of scaffolding, then an enhancement in learning opportunities for the students presents itself, enabling students to question, predict, infer, synthesize, and analyze information around texts, increasing their performance during science assessments. As such, both actors in the typical science environment (learners and teachers) can participate in knowledge construction actively.

Although there exists research on how scaffolding can be adopted to increase the understanding of science texts, little to no evidence exists on how the approach can be employed to improve performance, especially for students coming from low-income households that are more likely to perform poorly upon assessment. In reversing the gaps in student performance, there is a need to introduce empirical evidence that specifically facilitates effective scaffolding types that support teachers in administering basic scientific knowledge to high school students. Several studies have been carried out in high and elementary schooling settings to identify diverse types of scaffolding adopted in controlled situations. For example, Lo, Lui, and Wong (2019) note that in most science lessons, cognitive scaffolding was adopted.

On the other hand, while comparing the results of elementary science students, Chen, Hand, and Norton-Meier (2017) note that maintaining student participation was the pivotal intent. As such, trained teachers have more complex tasks in class and also adopt an equally great scaffolding mechanism during reading. However, the scaffolding intensity tends to reduce with time. Besides, when students understand the tasks, then teachers allow them to self-regulate their reading throughout the entire session. Furthermore, untrained teachers offer less complex tasks, with highly directive scaffolding. As such, it is not surprising that experimented students have a great interpretation of the taught subject matter. A study conducted by Kleickmann, Tröbst, Jonen, Vehmeyer, and Möller (2016) describes strategies adopted in the science class context in reading narrative texts. From the study, it was evident that learners gained a deeper understanding of the subject matter as they faced more challenges in learning. Notably, cognitive scaffolding was adopted in numerous instances during the revision of learned ideas and principles.

Consequently, cognitive scaffolding facilitates a deeper engagement in administering scientific disciplinary content. Also, interactive class lessons lead to reconstructed scientific understanding. From the reviewed studies, the central issues noted include the scaffolding types and the complexity of science tasks, which are evident in diverse classroom contexts and situations. The studies imply that scaffolding is directed to particular aspects of reading, which provide evidence that characterizes the complicated association between student participation and reading comprehension. However, it is still important to figure out how effective teachers adopt scaffolding in different disadvantaged contexts to improve student performance.

Conceptual Framework

Drawing from previously highlighted research, three dimensions can be selected to characterize the process of scaffolding comprehension of texts in typical science classes. These dimensions include the student's level of verbal participation, the function and type of scaffolding in interpreting scientific

texts, and the level of reading comprehension as promoted by the science tutor. Also, this literature review assumes that this role contextualizes all three dimensions.

The Levels of Reading Comprehension for Scientific Text

In understanding scientific texts, there are three comprehension levels, i.e., the critical, inferential, and literal. At the critical level, a reflection is done on what is brought up in the text and on how **information** is presented. At the inferential level, an interpretation is made from the content already known, and new information is integrated with the student's previous knowledge. Lastly, at the literal level, information is selected and recovered. Notably, this framework has previously been adopted in reading comprehension.

It has also been employed in characterizing the questions used by science tutors during reading activities in high school physics classes. As such, literal level questions push students in focusing on particular ideas, which enable learners to comprehend the information in the texts. On the other hand, inferential level questions construct a situational model in which previous knowledge is incorporated with meaning from the current text, which elaborates an in-depth and coherent representation of what the scientific text means. Lastly, critical or reflexive levels enable readers to judge the substance availed in written accounts, which empowers them to evaluate and question evidence, leading to discernment between evidence and various accepted accounts.

3 Functions and Types of Cognitive Scaffolds

Feedback Scaffolds

These types of cognitive scaffolds are adopted when evaluating the answers and reasoning given by learners during the cycle of communication. There are two types of feedback scaffolds, i.e., complementing and consolidating. During the complementing feedback scaffolding, the science tutor provides part of the answers by redirecting, reformulating, and adding to the question. On the other hand, the consolidating feedback scaffolding approach is utilized when explicitly signaling a fulfillment of the learning objective, through either recapitulation or confirmation.

Internal Scaffolds

These refer to the verbal cues that can be employed by teachers when science students are struggling during their reading activities. There are two types of internal scaffolds, i.e., pressing or internal noninvasive and contributing or internal invasive scaffolds. Pressing scaffolds pressurize learners into elaborating their initial responses by solving posed questions. On the other hand, contributing scaffolds refer to the kind of help offered by teachers to students, which aids in elaborating the given answer. This kind of scaffolding offers an option to answer 'no' or

'yes,' completes the answer, initiates responses from students, and provide visual cues.

Regulatory Scaffolds

Regulatory scaffolds are also referred to as pre-answering scaffolds. They are employed when illuminating the problem-space generated by each scientific question, encouraging students to participate in the class by actively searching for an answer. Besides, these types of scaffolds are used in highlighting starting points, meaning that they are offered before learners respond. They also highlight the goal begin pursued and the possible actions that are necessary to achieve the objective. As such, the student is intensely engaged in facing the task at hand.

The Verbal Participation of Students in Science Classes

The verbal participation of students during science classes implies that they are able to build meaning from various texts. In this case, the teacher acts as a bridge between their newly found knowledge and existing content. As such, it is expected that a transfer of responsibilities from the instructor to the student will aid in improving the student's experiences during reading, which enables them to increasingly become independent and authentic. Notably, there are five levels of verbal participation, i.e., the student constructing ideas without help from teachers, students participating more in the construction of ideas as teachers offer more deedback consolidative scaffolds, learners constructing dieas via diverse instructor scaffolds (feedback type), teachers adopting feedback and little to no participation from learners to construct iseas, and when the teacher single-handely elaborates upon the idea.

Such a classification represents the extent of responsibility expected from teachers and the learners. Notably, it is assued that fewer feedback and invasive scaffoldings completed results in lesser autonomy from students. Most importantly, the three dimensions described previously (students' verbal participation, the function and type of scaffolding, and level of reading comprehension) are all analytical categories of the current study, which dwells on recognizing the manner in which student-teacher interactions are articulated and produced when diverse excahnges are aimed at understanding scientific texts.

4 Methodologies

Participants

The participants in this study were Colonial high school students (Orange County) enrolled in two physics classes. Newtonian concepts. The scaffolding method of teaching was adoted in this study. Students in both classes were unaware that they would be subjected to a new model of teaching. One class was regarded as the "experimental" class, whereas the other one was regarded as the "control" class. The control class was taught through the traditional style of knowledge administration.

Experimental Design

The number of weekly hours differed for both classes. Both experimental and control classes were taught on diverse Newtonian concepts in physics. Notably, the researcher or instructor was very familiar with the subject matter administered to the students. In addition, the instructor was also aware of problems, challenges, and the characteristics of the typical high school physics classroom. The difference between the control and experimental classroom as ue to the approach that was selected in delivering instructions. As such, in the control classes, knowledge was administered in the traditional style, where the instructor lectured on different problem solving examples and physics concepts. Also, the instructor administred different reading qizzes and also offered homework to the learners. Most importantly, these activities were not practiced by the students and the instructor routinely.

On the other hand, students enrolled in the experimental classes did not have advance insights on being subjected to a different approach in teaching. Besides receiving additional explanations on physics concepts and solving problems in class, the science class in the experimental lessons were also involved in various other activities that were purposefully designed to fabricate a learning environment that foster interactive engagement. As such, reading reading quizzes were **administred** to the students prior each lesson. Notably, the questions were then discussed immediately to ensure that learners had to correct interpretation. Besides, the quizzes were marked, graded, and handed back to the students during the following lesson. Basic questions were asked, evaluating the students' knowledge on diverse association between variables.

Secondly, through interactive deintrations, the instructor initiated a demonstration but did not finalize it. Students were then prompted to discuss the outcomes of the demonstration with other learners. As such, they recorded their predictions, giving reasons that underlay those predictions, and handed in their sheets. The instructor scaned their predictions sheets and proceeded with the demonstration, grading the sheets, and handing them back during the next lecture. This process encouraged students to be involved intensely during each classroom activity. Thirdly, students were expected to respond verbally to the questions by the instructor on different Newtonian concepts taught in class, inclusive of explaining everyday phenomena. Most of the questions had multiple choices. Lastly, Active Learning Problem Sets (ALPS)

worksheets were also introduced to the students, which provided step-wise procedures in solving problems in physics. Notably, these worksheets included mathematics, physical, and pictorial

representations, offering the students with an exceptional opportunity to practice problem solvng. Besides, most of these worksheets were not graded since they had been provided for additional practice.

Measuring Instruments

Three measuring instruments were used in this research to indicate the effectiveness of the scaffolding techniques., i..e, questionnaires, end-of-terme exams, and force concept inventory. In measuring conceptual thinking abilities, the force conceptual inventory and midsemester exams were applied to students in both experimental and control classes. Since the study concentrated on student's understanding on Newtonian concepts, the evauation was done with topics covered as the semester began. The FCI was given twice to the students, with the first pre-test test being administered on the first day and the second post-test being given during the third week. The total time in taking the tests was about 45 minutes for tboth classes. On the other hand, the end-of-term exam was used to measure student's achievement.

The exam was based on the taught Newtonian concepts. Lastly, a questionnaire was administred to the students in the experimental class regarding their attitudes on the new mode of teaching. The questionnaire's items directly reflected on diverse elements during the teaching sessions. Before the questionnaire was distributed to the students, the instructor clearly notified the students of its intended purposes, which basically was to assess the reactions by learners to the teaching method and possibly make further adjustments for future application. **Results and Interpretation**

5 Results

Table 1: Results from the research.

Type of class	N	Pre-test mean	Post-test mean	<g>**	Exam score mean
Control class	50 students	20.3%	31.6%	0.13	42.5%
Experimental class	52 students	20.4%	42.3%	0.28	50.4%

NB: <g>** (the average normalized gain value) was calculated using the formulae below, where

S_i and S_f are the post-test and pre-test means scores for the students respectively.

$$<g> = \frac{\% <G>}{\% <G>_{max}} = \frac{\% <S_f> - \% <S_i>}{100 - \% <S_i>}$$

Interpretation

Conceptual Understanding

Notably, the narrow range in the pre-test scores for both experimental and control classes depicts that the initial knowledge of learners in both settings was quite similar and there was a random distribution across both samples. The low gains in the control class depict that there was no much improvement in traditional modes of knowledge integration in the classroom. As such, it is imperative to note that conventional modes of teaching physics have resulted to low performance amongst students. On the other hand, the experiemtnal classes had a higher gain factor. As such, it is evident that the experimental classes had a significantly greater understanding of the Newtonian concepts as compared to the control classes. Such an immense improvement results from the scaffolding techniques employed in knowledge intergration to raise the performance of students in science classes. These techniqes focused on the importance of interpreting concepts correctly, resulting in an enhanced level of comprehension amongst the students.

Problem Solving Skills amongst the Students

The results depict that the control class had an exam score of of 42.5, which is lower than the experimental class. On the other hand, the results of the experimental class were significantly higher compared to those of the control class, which implies that students subjected the scaffolding techniques had better problem solving skills compared to those who were instructed through conventional techniques. Notably, enhanced conceptual understanding must have contributed to the increased problem solving skills amongst the students. The exam questions considered did not exceed the student's ability as they were carefully scrutinized by the instructor. The first trial to change instructional practices reveals a huge increase in the student's performance and with more successive phases of implementation, it is evident that scaffolding techniques of knowledge intergration will result in more substantial improvement in the performance of students.

On the other hand, attitudes to the changed method of instruction in class might have affected students' reception of the scaffolding techniques. Notably, their frequency in practicing reading hand-outs and solving homework problems may be connected to the improved achievements at the end of the semester. As such, it is apparent that interactive scaffolding techniques improved the understanding of students in a physics science class. Lastly, students in the experimental class appraised the adoption of the new model of science instructions, while others preferred the traditional paradigm of teaching. Besides, the view that teaching must only be implemented through traditional or conventional techniques might have affected the student's reception of the new scaffolding techniqeues in knowledge integration.

6 Conclusions

Overall, there was a huge improvement in the comprehension of Newtonian concepts when scaffolding knowledge intergration techniques were adopted in the experimental physics class seting as compared to the control class, measured by the final mean exam scores. Notably, such an interactive class session enabled students to participate in the entire learning process, which helped in improving their overall performance and improvement. In this case, it is evident that the most effective method of instruction in

science classes is where knowledge is built by making reading and learning more demanding with questions that promote an in-depth understanding of the content being studied, offering students more chances to solve problems both orally (verbally) and in writing. As such, th results in this capstone project are due to the generation of new knowledge in low performers due to more demanding tasks in comprehensive reading and participation within the experimental class setting. Furthermore, the most effective science instructor not only adopts the reading activity in a bdi to access physic knowledge and evaluate learners comprehension, but also that learners might integrate and build their scientific knowledge from more sources.

Also, the less and more effective instructors differ in the level of understanding promoted within the science class setting. As such, better performing scaffolded sessions expose learners to reading activities where the questions are more open-ended, which demand higher cognitive capacities. While teachers with low performing students might adopt literal comprehension to a substantial extent, those affiliated with students improving their performance are known to administer constructive scaffolding models. Besides,

low performing students have limited opportunities in organizing, orienting, and addressing their comprehension of specific scientific material, since the questions offered in class focus on completing their responses. However, effective teaching models in invasive scaffolds adopted by more successful and highly perfomring high school students adopt non-invasive scaffolding where students have an exceptional opportunity of developing their responses. Lastly, it is evident that the most effective teacher in improving the performance of learners in a science class promotes greater verbal participation of students, which helps them to construct a coherent representation of read material. Less effective teachers buld meaning expressed in diverse readings, resulting in learners with little autonomy where their participation is limited to shorter answers.

Overall, the most effective scaffolding technique in improving learners comprehension of scientific content bulds knowledge through formulating inferential questions. These questions fabricate a coherent representation of the etxt read by learners, with verbal participation and cognitive scaffolding that result in the development of challenging, dynamic, and autonomus learning. The instructor, in this study, scaffolded the challenging class tasks to learning expsitry material in an in-depth manner , which provided less invasive scaffolds. As such, the highly effective teaching method (scaffoldingknowledge integration) activates the prior knowledge of students and introduces better ideas, forcing an in-depth comprehension and understanding of texts within physics science classes. This study will impact Colonial high school in Orange County by improving the achievement of low performing students. Also, this study will improve the manner in which learning is effectively scaffolded to comprehend physics texts that are linguistically and cognitively challenging.

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