SUPPORTING ENGLISH LANGUAGE LEARNERS' STUDENTS IN HIGH SCHOOL PHYSICS

by

Farrah Cooper

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2021

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ABSTRACT

The study's main aim is to investigate ways of supporting English Language Learners (ELLs) in the High School Physics Classroom and identify the best mode of differentiating instructions. The research focused on how instructors can help English Language Learning students in a physics classroom. The conclusions and recommendations that are made are based on findings from the primary data. The inductive research approach was very significant in understanding the experience of the ELLs before and after experiencing both teaching techniques. Therefore, it was clear that many schools have students who are learning English as a second language. Thus, students must be ready for the smooth grasping of both mathematical and scientific concepts. However, the research also has some limitations. For example, the sample size used is very small to gather enough evidence. In addition, the study used very few. Therefore, further research should be done on larger sample size for better results in the future.

INTRODUCTION AND BACKGROUND

English as a Second Language

Learning English as a second language is given a higher priority in the current world. Every state and country emphasizes various ways of promoting English as a learning process through the entire curriculum. Although physic is one of the most technical subjects in their curriculum, most of the terms and concepts are hard to discuss and explain in various languages compared to the English language. Furthermore, there is an increasing interest in learning physics, particularly in high school and universities, which results in an increase in learning English as a second language or as a first language (Roberts et al., 2017).

English is not only a language of instruction but also a language of technology and science. With the projected shifts in our nation's population, we are likely to witness an increase in the number of English Language Learners (ELL) students. Currently, a significant number of students within the educational system are learning English as a second language. Equally, the number of ELL students in high school taking physics has also increased and will continue to do so in the future. Teaching physics in English as a foreign language has become necessary as new ideas in advanced science, and it has become problematic to translate everything into various languages. As a result, most of the new concepts are published in English. In order to keep up with fresh ideas in most concepts, learners need English-based instructions.

More learners need English to study at different educational levels, such as high school and colleges. In addition, the English language plays a significant role in forming and developing knowledge concerning other concepts related to physics. Thus, English is used as a tool to construct cognitive images and structures necessary in learning physics concepts. Additionally, learning physics necessitates reading, comprehension of scientific concepts, and communicating about the concepts.

Reading through the work of various researchers, I realized ELL students tend to face numerous instructional challenges due to their low English proficiency. This gave me an additional significant hint concerning these students' suffering, requiring immediate and close attention. For example, I realized that teaching physics to ELLs was challenging, mainly due to language differences. I further observed that challenges of learning physics among ELL students could be categorized as teacher-related, student-related, and institutional-related. I also observed that students using English as a second language to learn science were likely to encounter additional language problems. Through this, I realized the extensiveness of the issue at hand.

Besides, my pedagogical knowledge convinced me that students that are learning a subject, such as physics in a language they do not master that well, would present serious challenges to them. The issues are likely to stem from the fact that a majority of them are ill-equipped in the English language to understand materials or learning resources presented to them altogether. Listening to physics instructions given in English is a task. Additionally, reading texts full of technical vocabulary related to physics is a considerable challenge. Now that I have a clear picture of the problem, what should I do? I believed that everyone could secure a decent life throughout my academic life if they excel in a specific domain. How can teaching physics and learning be facilitated among

ELL students at the high school level so that they do not view it as a difficult discipline? I thought I should problematize this challenge and dispel the myth that physics is a difficult subject for ELL students.

The Background of the Study

Houston is a very diverse city where residents do not share a common language. Though most people are fluent English speakers, part of the population is not. Consequently, a majority of schools within the city have introduced English as a foreign language. Teachers in these schools must teach subjects in science, such as physics, in English as the medium of instruction. However, using a second language as a medium of instruction has proved problematic in teaching and learning physics among ELLs. This has had a detrimental effect on these students' academic achievement, which has attracted my attention. After the persistence of the issue over my teaching career, I felt I should seek a solution to help ELLs struggling in their physics classes. As a teacher, I always feel disturbed if there is a problem facing my learners that is unresolved.

Teachers and other interested stakeholders continue to look and devise new approaches to support ELL students undertaking physics in high school (Carroll, 2018; Wells, 2014). This classroom project's primary concern is to present the steps taken to find ways to enhance physics' teaching and learning process, focusing on supporting ELL students. Additionally, this current project aims to provide insights to ELL teachers to support their high school physics students. The capstone project offers resources and guidance teaching strategies to support ELL students undertaking physics in a high school setting. The project was developed since there is a need to support these students in understanding and communicating physics class ideas. Currently, the standard physics classes have a considerably high linguistic demand. Learners are expected to work collaboratively to propose solutions to problems, ask questions, provide feedback, offer an explanation, and construct arguments and counter-arguments supported by evidence. Learners of English as a second language require support to help them develop the academic vocabulary and language structures critical to meet the language and content objectives of physic classes. Accordingly, the learners' learning outcomes can be improved by providing quality support. In this regard, the current project aims to offer constructive and positive reinforcement to ELL students in physics classes at the given high school settings. The teacher's role is to ensure a favorable learning environment characterized by appropriate support. In addition, offering a supportive learning environment to the ELL students would increase the mastery of teaching physics concepts.

Although this capstone project is developed for a specific high school setting, the presented resources would help any educator who works with ELLs undertaking physic classes. Some of the recommendations, resources, and teaching strategies provided may also apply to higher education. Besides, though this project is created and involved the high school physics students, it would serve as an example of how educators can support their students' oral language development.

I hoped to achieve various objectives through this research project. First, to support ELL students in high school physics to help them comprehend instructions. Secondly, to increase these learners' motivation and confidence by ensuring an accurate understanding of physic concepts. A precise comprehension of major physics concepts can be a motivating factor and means to boost ELL students' self-confidence. Finally, I wanted to support learners in recording vocabulary relevant to physics content. The intent was to help students find the strategies that work best to keep track of new terminologies to use in the future as references in their discussions or writings.

In this project, I present a novel approach to support ELL students in high school physics. My colleagues handling similar physics classes can borrow a leaf out of this project and adopt different support mechanisms. Adaption and implementation of some of the support approaches would improve the physics' learning process among ELLs. In return, ELL students taking physics classes would gain the English proficiency needed to learn significant concepts of this particular discipline.

Several aspects triggered me to conduct this classroom project by the first-hand experience regarding instructional challenges ELL students experience taking a physics class. As a result of these challenges, most of the students lose interest in the subject. I am questioning myself, why do these learners lose interest in physics? Having experienced such difficulties within the classroom setting, I feel that these learners require support to develop their ability to use precise domain language to adequately describe and explain various physics concepts they learned in English. So, how can I motivate these students through the English language? I had to find ways to offer support that enabled the learners to acquire the technical vocabulary necessary to comprehend key physics concepts. I felt this vital concern as I am part of the stakeholder and context in high school education; thus, I have to do something meaningful for the community.

Focus Statement

My perception concerning the need to offer appropriate support to these ELL students in my physics class resulted in developing the main focus statement: what are the effects of support among ELL students in a physics class in high school? Based on these premises, I will focus on the following research inquires to guide this project. First, how can instructors support teaching physics concepts to English language learners? Next, what are the learning gains when teachers offer support to ELL students in physics class? Lastly, what strategies should we provide to support ELL students in the physics unit classroom?

LITERATURE REVIEW

Factors Affecting Learning among English Language Learner Students

Various researchers have presented multiple factors which affect the knowledge among English learner students. These factors include learning process, learning conditions, leaner personality, which provides for anxiety, risk-taking, and self-confidence. The social factors and learning outcome also influence the students' attitude and how they learn the English language. Learner personality context is a prominent factor in the learning process; it consists of learners' attitudinal and personal aspects. At the same time, attitudinal factors determine language acquisition which can contribute to sustained classroom atmosphere created and a low affective filter not by the learner but by the teacher. Self-confidence is another factor; it demonstrates learners' confidence and ability to learn. The student's tendency to have anxiety is another factor that tends to be consistent with language proficiency, learning situation, personality. Educational context gives learners the opportunity of learning and speaking the target language in the community. Researchers have also argued that learning situations affect the learner's attitudes and their success. The final factor is the foreign language teacher, teacher's experience, and favorable feelings with students' learning materials positively impact learning English as a second language (El-Omari, 2016).

Learner Motivation among English Language Learners

Learner motivation is one of the most significant factors that affect the acquisition of a language and concepts in class. Generally, motivation is a factor that determines an individual's desire to accomplish whatever they choose to undertake (Steinmayr et al., 2019). From the perspective of learning, motivation is a learner's overall goal, self-drive, attitude, and persistence shown towards acquiring education. In this regard, learners who desire to learn are likely to accomplish more than those without this desire (Lacambra, 2016). In addition, learners who are motivated will have the determination to solve and overcome whatever challenges they face.

Motivation can be clustered depending on the source and the need to accomplish learning (Bal-Taştanet al., 2018). For instance, there are integrative and instrumental categories. Integrative motivation is where one learns because they have an interest in the subject. On the other hand, instrumental motivation is where one seeks to learn a subject because they see it as applicable in order to achieve career goals or pass an exam (Adamma, et al., 2018).

Motivation can also be intrinsic or extrinsic motivation. Intrinsic motivation is where one undertakes an activity, but there is no ostensible benefit except the action itself (Miao et al., 2020). As such, one is motivated only because of inherent feelings of self-actualization and competence. On the other hand, extrinsic motivation is a reward such as monetary benefits and positive feedback. After making comparisons, the extrinsic motivations lead to higher success in learning, particularly in the long term.

The Challenges of Learning and Teaching Physics to English Language Learners

The challenges of learning and teaching physics to ELLs can be classified into teacher-related, institutional, and student-related challenges (Dias-Lacy & Guirguis, 2017). Teacher-related challenges denote scenarios where the teacher may not be motivated, fail to comprehend their role, and incompetent. For instance, the instructional strategies adopted by different physics teachers would influence ELL's understanding of the subject. For example, some teachers may continue the traditional teaching approaches where the focus is on knowledge of facts and processes or presenting scientific facts to be learned instead of developing students' understanding (Mulhall & Gunstone, 2012). Contrarily, other teachers may adopt a constructivists approach to teaching. As a result, the students have opportunities to discuss physics ideas and problems to foster intellectual engagement, knowledge, and understanding.

Student-related challenges are those presented by a group of learners, such as lack of motivation and cultural differences (Dias-Lacy & Guirguis, 2017). Institutional challenges are those created by the school, and they include a lack of management support and provision of inadequate resources. Given that most ELL students are immigrants, a class will have students of different cultures, ethnicities, socioeconomic statuses, and educational backgrounds (Kondo, 2018). This presents a challenge of handling the diversities for teachers and learners seeking to interact among themselves and learn from one another. In addition, some of the ELL students have low language proficiency hence face a challenge in overcoming the new language barrier while simultaneously trying to comprehend content for a subject like physics and use it in their new environment (Bunch, 2013). Therefore, a teacher must consider all the diversity when planning on teaching strategies.

Teaching and Learning Strategies for ELL Students

Learners adopt many strategies which enable them to comprehend instructions. Learning strategies denote several tactics that students employ in order to control a learning process and achieve the expected outcome (Hartikainen et al., 2019). Developing effective learning strategies is one of the instructor's primary responsibilities to facilitate effective learning. To teach effectively, instructors should consider each student's needs and ability to develop and implement strategies that improve the learning process (Guerriero, 2019).

A teaching strategy is a plan for delivering a lesson that includes structure, objectives, and tactics (Lysniak et al., 2019). Teaching a class entails a combination of activities and some decisions, which the instructor should align with the priorities of their work and develop strategies in line with the curriculum (Darling-Hammond et al., 2020). In this regard, a teacher should create a rational and suitable plan that combines methods, techniques, and procedures, leading to optimal outcomes (Darling-Hammond et al., 2020).

Teaching strategies should enable learners to maximize learning outcomes in their respective subjects. For instance, the students' physics-related experiences are significant for reflection when solving problems, developing conceptual understanding, and elevating their general world view. In addition, teachers should implement strategies that realize productive experiences which enable them to view the world differently (Wells, 2014). To achieve this, teachers can utilize classroom activities that allow students to view the world through their eyes. Thus, they leave classrooms after understanding physics and its role in solving daily life challenges (Bao et al., 2019).

One of the strategies that enable students to comprehend physics and its role in daily world life is Interactive Engagement (Bogusevschi et al., 2020). Interactive Engagements allow students to spend time in class working and solving real-world problems as opposed to passively listening to lectures (Deslauriers et al., 2019). The strategy requires students to express their perspectives and communicate with the instructor besides taking notes. The teaching strategy entails using group work, peer discussions among the students, modeling of real-world problems, and multiple representations. The use of models enables students to make assumptions necessary to solve problems and practice making sense of real-world topics in the course studied (Carroll, 2018). Group discussions allow students to have opportunities to discuss their perspectives, share opinions and enhance individual thinking while learning from one another (Bao et al., 2019). This strategy also supports struggling students and enables them to improve their academic performance. The use of representations in the classroom provides students with words, equations, graphs, and physics pictures. Further, it emphasizes that physics teachers implementing Interactive Engagements should encourage collaborative work, develop an active learning environment, and use real-world problems and laboratories to optimize conceptual understanding.

Role of the Teacher in Instructing ELLs

External and internal factors influence the role of a teacher. In particular, internal factors include an instructor's perception of their role. The teachers themselves form the internal factors, which provide for their beliefs and expectations on their role (Viberg, et al., 2019). Generally, their ideas are often not determined by an expert or professional knowledge. This shows that teachers can have different beliefs based on culture, age, level of training and experience, and background. External factors are those driven by expectations and views on the instructor's role from stakeholders such as school management, students, colleagues, regulators, parents, and the general public (Cicekci & Sadik, 2019). External and internal factors are essential in the creation of a teacher's identity. Therefore, teachers should fulfill external expectations, especially those of stakeholders, and align their personal beliefs and perceptions to their immediate environment.

Teachers have important and indispensable roles besides instructing. The primary responsibility of a teacher is to offer instructions and guide learners as per the curriculum (Viberg et al., 2019). The teacher has a task with nurturing and sustaining a friendly environment that supports learning. A conducive learning environment entails the class atmosphere, school culture, physical space, resource availability, and interactions between teachers and students (Abualro, 2019). For instance, there should be freedom of interaction between students and teachers to increase teaching outcomes. Teachers are responsible for developing a safe learning environment.

Teaching Physics to English Language Learners

The scientific inquiry method of teaching is where students seek information and understand concepts by questioning and performing experiments when necessary. Students make observations, seek solutions to problems as they develop new knowledge. In the process, students can examine books and other sources of information to see what is already known, review the knowledge in relation to findings from experiments, collect and analyze data, propose new solutions and communicate the results. This shows that the teaching methods are not limited to scientific language and scientific reasoning and include making sense by connecting it to everyday experience. In a high school physics class, the scientific inquiry takes collaborative and collective activities where teachers include more hands-on activities.

The use of scientific inquiry has benefits and challenges to all students and, by extension, the ELL students. One advantage of scientific inquiry is that students learn by taking an active role which increases comprehension and application of knowledge (Sotakova,et al., 2020). This method also improves students' attitudes towards science and enhances interest, curiosity which increases chances of liking the subject compared to the traditional lecture method. On the other hand, the traditional method can be boring because it is a common approach that entails writing with little practical activity. Generally, students are simply recipients of the information.

Traditional methods enable teachers to address unique student challenges and motivate them compared to scientific inquiry (Roehrig & Luft, 2019). Through face-to-face lectures, teachers can offer step-by-step guidance to help ELL students understand the content instead of learning it only on their own, which can be confusing. Therefore, many scientists advocated for traditional methods that consist of planned interactions that enable students to learn new skills.

However, traditional lectures have some limitations. For instance, it limits students' ability to make judgments compared to scientific inquiry (Aranda et al., 2019). This is the case when students focus on memorizing information as emphasized by their teachers during science lessons. In addition, traditional lectures only work when content is delivered, and there are discussions between teachers and students. When there is no discussion and deliberations, traditional instruction does not foster the development of ELL students.

Visualization entails the use of graphs, pictures, and other visuals as teaching tools. Visual literacy and the capability to understand graphical representation are moderately independent of language (McNeil, 2015). Therefore, it is an effective method to teach physics to ELL students. This is achieved by using visuals such as graphs that introduce concepts to encourage meaningful learning and integrate new and familiar ideas (Kurnaz & Eksi, 2015). The use of visualizations enables a teacher to communicate concepts with minimal use of spoken or written language. However, the presentation should be a clear and uncluttered layout.

Authentic learning is an instructional approach that allows students to explore, discuss, and expressively construct concepts and relationships in contexts that entail real-world problems and projects that are relevant to the learner (Chin et al., 2015). Teachers can achieve this through main concepts such as real-world applicability of tasks, student-directed learning, exploration and collaboration, and mastery of critical concepts.

Real-world applicability of tasks is where students are solving tasks, and they are provided with knowledge that is applicable outside the classroom (Hody & Sagy, 2019). In addition, students are made aware of the relevance of what they are studying. On the other hand, student-directed learning is where a teacher facilitates, guides, and provides students with well-thought tasks and concepts that enable them to solve problems and acquire necessary skills.

The concept of exploration and collaboration is where learners mimic real-life situations and solve tasks in groups (Bani-Hamad & Abdullah, 2019). This can develop and nurture their teamwork skills and learn from one another. Finally, the mastery of critical concepts is where real-life skills are acquired through knowledge of key ideas and applying them to solve problems (Bani-Hamad & Abdullah, 2019).

Summary

English Language Learner students pose different instructional challenges due to their low English proficiency. Learners' speaking ability, listening skills, and feedback from teachers, language differences between their first language and English influence their ability to internalize physics concepts. Teachers should focus on providing extrinsic motivation as it is associated with higher success in the long term (Adamma et al., 2018). Further, physics teachers are encouraged to adopt a constructivist teaching approach to foster intellectual engagement, knowledge, and understanding (Mulhall & Gunstone, 2012).

METHODOLOGY

Introduction

This research investigates ways to support English Language Learners (ELLs) in the High School Physics Classroom and identify the best mode of differentiating instructions. The choice of methodology should correlate with the researcher's philosophical position and analyzed social phenomena (Swanson et al., 2014). Therefore, to accomplish the aim of the study, this section will discuss the underpinning research philosophy, design and research strategies, the methods used to collect the data, ethical considerations, and the limitations of the research methods techniques used. Furthermore, the methodologies listed help explore how instructors support teaching English language learners in physics classrooms, the gains and benefits to students learning the English language in the physics classroom, and finally, to identify the best strategies that instructors can use to support the ELLs.

Philosophy of Research

The philosophy reflects the thoughts of the research-on-research strategies, formulation of the problem, data collections, processing of the data, and data analysis. The researcher utilizes positivism philosophy to understand the best strategies for the instructors to support ELLs in learning physics. The inductive research methods were used to understand the students' experience before implementing the scientific inquiry method, authentic learning and visualization, and traditional learning method. In addition, the positivism research methodology enabled the researcher to gather first-hand information from the selected participants to provide an in-depth research topic.

Project Methodology and Design

Investigating how instructors can support the English Language Learning students in a physics classroom is quantitative nature of research (Lee, Quinn, & Valdés, 2013). The conclusions and recommendations are based on findings from the primary data. The inductive research approach is very significant in understanding the experience of the ELLs before and after experiencing both teaching techniques.

The inductive approach incorporates the qualitative methods that used mixed methods to explore the research topic (Brynjolfsson & Saunders, 2009). Both qualitative and quantitative research methods are used to collect the data. The quantitative techniques correlated with positivism research philosophy apply in designing the questionnaire in context with research questions. The quantitative techniques associated with the positivism research philosophy were used to design the questionnaire in context with research. The researcher used qualitative methods to gather reliable data on the students' experiences and identify the best learning strategy that efficiently supports English Language Learning students.

The non-probability technique used the sampling strategy to explain the evidence supporting the study's research questions. The sample size for the study focused on the students who are learning the English language with their consent. Due to the pandemic, small sample size was identified to provide essential data for analysis. The non-probability sampling technique for a small sample size was appropriate given the small timeframe to collect the data. The descriptive method uses the ability to profile the problem of the research. The researcher analyzes the collected data from a small size through the designed questionnaire. A quasi-experimental pretest-posttest design is implemented in the project. This design entails collecting data before implementing the intervention and after the intervention, then collecting data to determine its effect on the desired outcome (Jourabchi et al., 2020). The students in this research were subjected to two different teaching strategies, and data compiled for comparison purposes.

The designs applicable in the project enabled the researcher to determine authentic learning, visualization combined with the traditional method compared to scientific inquiry in teaching physics to ELL students. In addition, the design enabled data collection on students' performance before and after the implementation of the teaching methods. Finally, analysis of the results helped to identify the effectiveness of each technique.

Population and Sample Selection

Target population denotes the total number of subjects from which data can be collected in line with a research objective. The target population will be English Language Learners students enrolled in the physics course at Westfield High School in Houston, Texas. The students were from the same high school hence have a comparable environment such as discussion among peers, which is significant considering they will be ELL students. However, having a target population from different schools can be challenging, given that the differences in schools can be a confounding factor.

Convenience sampling will be used to sample students to take part in the study. A convenience sample is a non-probability sampling method where the sample is taken from students who are easy to contact or reach. The researcher is a teacher within the school where the study was undertaken, and it was convenient to sample from the classes. Further, the project entails implementing physics teaching methods that could be challenging to implement and collect data from another institution. Each school has its instructors hence will be reluctant to allow another teacher to instruct their students.

The students will be sampled in line with an inclusion and exclusion criterion such that only those who have desired traits will be recruited into the research. In addition, the students must be classified as ELL in line with the federal guidelines. In particular, according to the federal government, an ELL is a high school student who has another language apart from English as their native language and exhibits challenges in writing, reading, speaking, or comprehending English which affects their academic performance. Therefore, the researcher will sample 40 students who have been classified as ELL in line with the federal classification.

Instrumentation

The data were collected from implementing authentic learning, visualization combined with traditional lecture and scientific inquiry teaching strategies. The teaching strategies were implemented within the classes in line with the teaching curriculum for the ELL students who attended the class sessions. The researcher/teacher of the record captured students' attendance, and only those who will complete the session were part of the data collection.

Data Collection and Analysis Strategies

In line with the research design, data were collected upon implementation of the strategies. The students were surveyed with a questionnaire to rate the teaching strategies. The questionnaire had the same questions for the teaching strategies under comparison. Each teaching strategy was implemented separately and within the classes in line with curriculum and teaching guidelines. The methods were implemented where students attended classes designed to deliver relevant content. The researcher kept all the records of class attendance.

Descriptive and inferential statistics and a particular measure of central tendency are used to summarize and describe the data. In addition, mean, median, and standard deviation will summarize the data also. The summaries will be presented in graphs and tables. In order to explore the effect of strategies, an independent *t*-test is used. The independent variable is participation in the teaching method, while the dependent variable is student performance. An Independent *t*-test is used to explore if there is a significant difference between the two means; hence it is in line with the pretest-posttest design used in the project (Gerald, 2018). The analysis will be conducted at a 5% level of significance, and the independent t-test will be used to compare if the difference in means is significant.

Ethical Considerations

The research methodology for this project received an exemption from Montana State University's Institutional Review Board, and compliance for working with human subjects was maintained. The researcher sought permission from the institution before commencing the project. This will be realized by providing the school management with the project proposal, highlighting what was required, and obtaining approval to use the school facilities for the study. The researcher received permission to use student performance details in the research. No personally identifiable information was collected or revealed during the data collection process. In particular, no student names and admission numbers were captured in the data collection tools. The researcher has maintained the anonymity of the participants. The data collected is secured in a password file only accessible by the researcher.

Limitations

One limitation of the study is the use of convenience sampling. This sampling technique does not produce a representative sample; hence the findings cannot be applied to a broader population (Etikan et al., 2016). Additionally, the sampling from the same class increases the homogeneity of the sample, which reduces generalizability. The sample size of 40 is small, which also limits the generalizability of the findings. From a small sample size, it is possible that the participants have similar traits, which affects the robustness of the results.

Data Analysis

Demographics

Spring ISD, a school district in Houston, TX, has approximately 36,000 students, of which approx 3,600 students are attending Westfield High School. The ethnic breakdown is 38.9% African American, 37.6% Hispanic, 18.6% White, and 4.6% Asian. In addition, 27.8% of students are in bilingual and English language learning programs. A total of 40 students enrolled in physics participated in this project, whereby 22 of them were male while 18 were female.

Before Students Experiencing Both Methods

The study showed that most students agreed that authentic learning, visualization, and traditional lecture enabled them to understand more mathematical physics concepts such as measurement, as evident from 63% and 55%, respectively. There was a similar trend when the students were asked to compare the methods with regard to comprehension and application. In particular, 60% believed that authentic learning, visualization, and traditional lecture enabled them to analyze the lesson and understand the puzzling aspects of the topics. In comparison, 53% had the same opinion that the method promoted students' understanding and relation of concepts to their daily life application compared to scientific inquiry. On the other hand, the same study showed that most students (58%) believed that scientific inquiry enabled them to stimulate their thinking compared to authentic learning, visualization, and traditional lecture.

A majority of the students agreed that authentic learning, visualization, and traditional lecture enabled them to better integrate the concepts with real life, as evident from 63%. Similarly, 60% and 50% thought that traditional lessons helped them remember important laws and equations and learn independently. When asked which method offered them critical thinking, half of the students voiced that both ways were the same. The findings showed that 63% of the students also believed that authentic learning, visualization, and traditional lecture encouraged them to engage in discussions with their teachers and peers. A similar proportion of the students had the same opinion regarding contextualizing vocabularies. As far as authentic learning, visualization, and the traditional lecture were concerned, 65% believed that it helped them communicate the content knowledge better. In comparison, 70% agreed that the teaching strategy was more effective in understanding physics' specialized vocabulary better. An equal proportion of 68% decided that authentic learning, visualization, and the traditional lecture was the better method in enabling students to understand technical terms.

Table 1. Physics-related aspects before students experiencing both methods.

	Scientific Inquiry	Authentic learning, visualization, and traditional lecture
Which method enables you to understand more?	38%	63%
Which method enables you to understand concepts of measurement?	45%	55%
Which method enables you to understand puzzling aspects of topics?	40%	60%
Which method enables you to encourage daily life application of concepts?	48%	53%
Which method enables you to simulate your thinking?	58%	43%
Which method enables you to integrate concepts with real-life better?	38%	63%
Which method enables you to helps you remember important laws and equations?	40%	60%
Which method enables you to learn independently?	50%	50%
Which method enables you to think critically and logically?	50%	50%
Which method enables you to discuss with the teacher?	38%	63%
Which method enables you to contextualize vocabularies better?	38%	63%
Which method enables you to communicate the content knowledge, particularly in science concepts, better?	35%	65%
Which method enables you to understand physics' specialized words better?	30%	70%
Which method enables you to understand technical terms?	33%	68%
Which method enables you to understand non-technical terms?	33%	68%

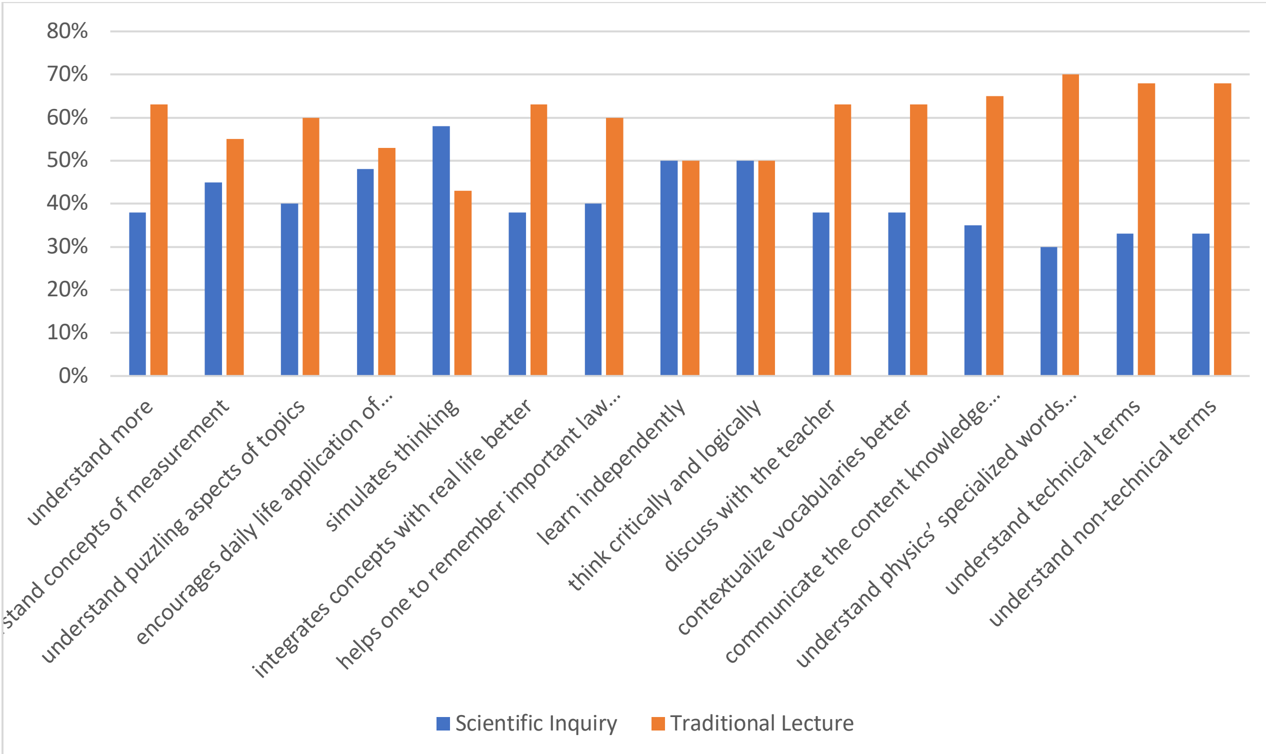

Figure 1. Physics-related aspects before students experiencing scientific inquiry, and authentic learning, visualization with traditional lecture, (N=40).

The instrumentation analysis showed that 60% said that authentic learning, visualization, and traditional lecture met the needs of their reading challenges better, while 63% said it enables them also to manage foreign language anxiety. Similarly, authentic learning, visualization, and traditional lectures helped them collaborate with other students, as evidenced by 70%. Furthermore, it showed that most students agreed that the authentic learning, visualization, and conventional lecture method enabled them to attain proficiency in conversational English and written English, as shown from 73% and 75%, respectively. Further, 80% said the traditional lecture was effective in improving language accent (Table 2).

Table 2. Language-related aspects after students experiencing both methods.

	Scientific Inquiry	Authentic learning, visualization, and traditional lecture
Which method meets the needs of your reading challenges better?	40%	60%
Which method enables you to manage foreign language anxiety?	38%	63%
Which method enables you to discuss and learn from other students?	30%	70%
Which method enables you to attain written English proficiency?	28%	73%
Which method enables you to attain spoken English written proficiency?	25%	75%
Which method enables you to improve your language accent?	20%	80%

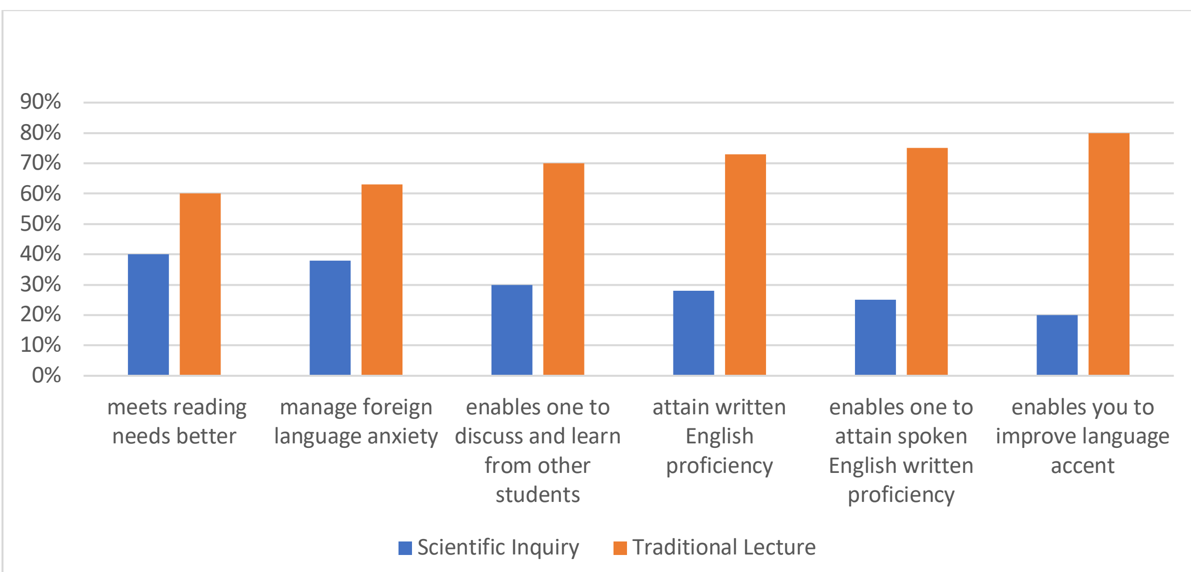

Figure 2. Language-related aspects after students experiencing scientific inquiry and visualization with traditional lecture, (N=40).

After Students Experiencing Scientific Inquiry, and Authentic Learning, Visualization with Traditional Lecture

The findings in Table 3 showed that most students agreed that authentic learning, visualization, and traditional lectures enabled the students to analyze more concepts of mathematical physics such as measurement, as evident from 75% and 65%, respectively. There was a similar trend when students were asked to compare the methods with regard to comprehension and application. In particular, 60% were of the view that authentic learning, visualization, and traditional lectures enabled them to understand puzzling aspects of topics. In comparison, 63% had the same opinion that the technique encouraged daily life application of concepts compared to scientific inquiry. On the other hand, the findings showed that most students (50%) were of the opinion that scientific inquiry enabled them to stimulate their thinking compared to authentic learning, visualization, and traditional lecture. Furthermore, most students agreed that authentic learning, visualization, and traditional way encouraged them to integrate concepts with real-life better, as evident from 63%. Similarly, 63% and 70% believed that authentic learning, visualization, and traditional lecture enabled them to remember important laws and equations and learn independently.

When asked which method offered them critical thinking, half of the students voiced that both ways were the same (Table 3). The findings showed that 73% of the students also believed that authentic learning, visualization, and traditional lecture encouraged them to engage in discussions with their teachers and peers. A similar proportion of the students had the same opinion regarding contextualizing vocabularies.

As far as authentic learning, visualization, and the traditional lecture were concerned, 70% believed it helped them communicate the content knowledge better. In comparison, 70% agreed that the teaching strategy was more effective in understanding physics' specialized vocabulary better. An equal proportion of 73% decided that authentic learning, visualization, and the traditional lecture were better methods in enabling students to understand technical terms. In comparison, 75% had the same opinions when asked about the understanding of non-technical terms (Table 3)

Table 3. Physics-related aspects after students experiencing both methods

	Scientific Inquiry	Authentic learning, visualization, and traditional lecture
Which method enables you to understand more?	28%	73%
Which method enables you to understand concepts of measurement?	35%	65%
Which method enables you to understand puzzling aspects of topics?	40%	60%
Which method enables you to encourage daily life application of concepts?	38%	63%
Which method enables you to simulate your thinking?	50%	50%
Which method enables you to integrate concepts with real-life better?	38%	63%
Which method enables you to helps you remember important laws and equations?	30%	70%
Which method enables you to learn independently?	45%	55%
Which method enables you to think critically and logically?	45%	55%
Which method enables you to discuss with the teacher?	28%	73%
Which method enables you to contextualize vocabularies better?	30%	70%

Which method enables you to communicate the content knowledge, particularly in science concepts, better?	30%	70%
Which method enables you to understand physics' specialized words better?	30%	70%
Which method enables you to understand technical terms?	28%	73%
Which method enables you to understand non-technical terms?	25%	75%

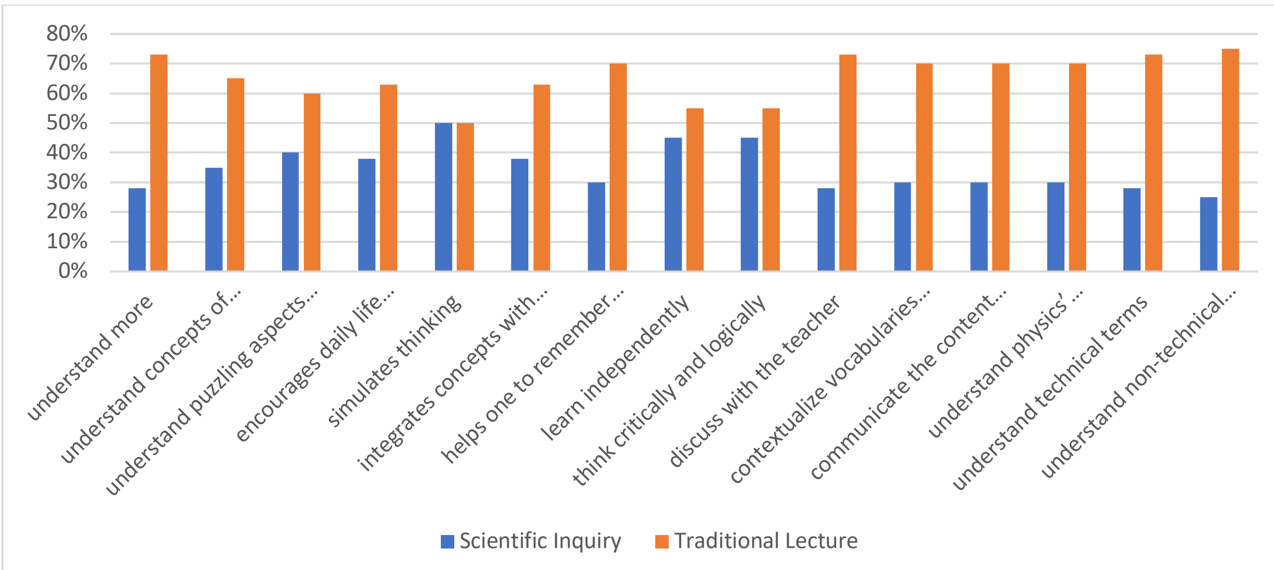

Figure 3. Physics-related aspects before students experiencing scientific inquiry, and authentic learning, visualization with traditional lecture, (N=40).

The study showed that 63% said that authentic learning, visualization, and traditional lecture met the needs of their reading challenges better, while 73% said it enables them also to manage foreign language anxiety. Similarly, authentic learning, visualization, and traditional lectures helped them collaborate with other students, as evidenced by 70%. In addition, the findings in Table 3 showed that most students agreed that the authentic learning, visualization, and conventional lecture method enabled them to attain proficiency in conversational English and written English, as shown from 83%

and 88%, respectively. Further, 83% said the traditional lecture was effective in improving language accent.

Table 4. Language related aspects after students experiencing both methods

	Scientific Inquiry	Authentic learning, visualization and Traditional Lecture
Which method meets the needs of your reading challenges better?	38%	63%
Which method enables you to manage foreign language anxiety?	28%	73%
Which method enables you to discuss and learn from other students?	35%	65%
Which method enables you to attain written English proficiency?	18%	83%
Which method enables you to attain spoken English written proficiency?	13%	88%
Which method enables you to improve your language accent?	18%	83%

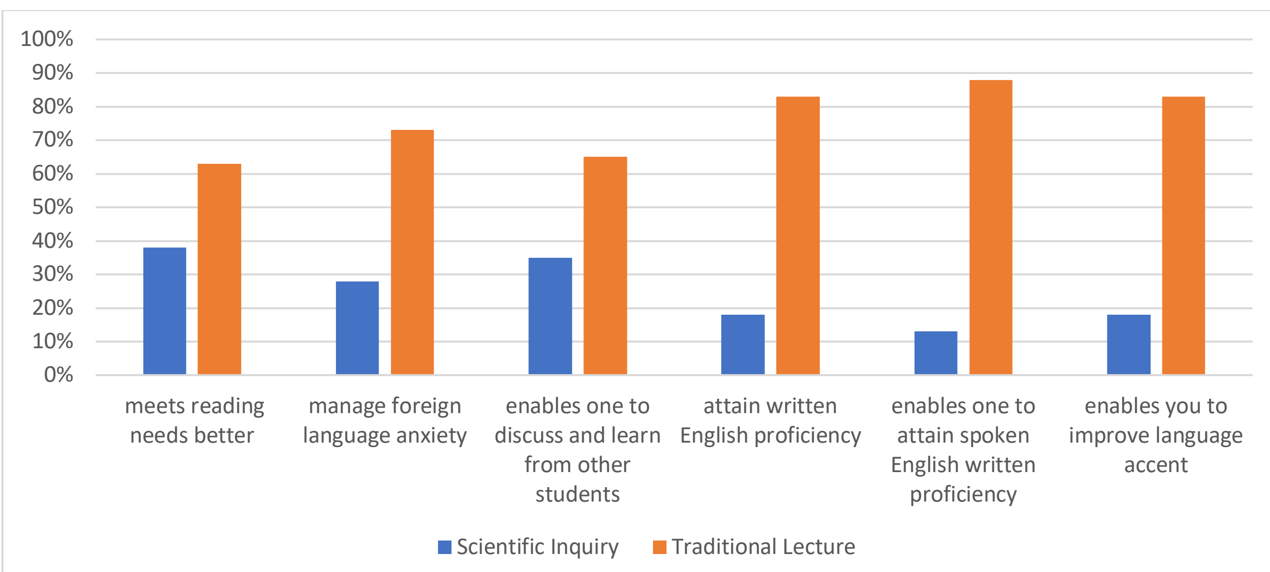

Figure 4. Language related aspects after students experiencing scientific inquiry, and authentic learning, visualization with traditional lecture, (N=40).

Inferential Analysis

The Paired Samples Test was used to compare if there was a significant difference between the two teaching methods. The figures in table 5 below showed the analysis yielded $P<0.05$; hence the null hypothesis of no difference was rejected. This showed that authentic learning, visualization, and traditional lectures had a higher effect than scientific inquiry.

Comparison

This section compares the efficiency of the two teaching strategies as captured by the questionnaire. A keen look at the findings shows that there were changes for the two teaching methods while there was no change in some cases. With regard to physics-related aspects, before students experiencing both methods, the study shows that there was an increase in its preference. The highest increment was the method that enables students to think critically and logically. Most of the positive changes were below 10%. This implies that after students experienced both methods, they preferred the other methods to scientific inquiry. There was a similar trend concerning language-related aspects after students experiencing both methods. The results show that there were increments ranging between 3% and 13%. An independent *t*-test was used to determine if these changes were significant.

Table 5. Paired t-test results

Paired sample t-test results

95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
Lower	Upper			
-15.806	-8.99397	-7.808	14	0.000

INTERPRETATION AND CONCLUSION

The results showed that authentic learning, visualization, and traditional lecture were better teaching strategies than scientific inquiry for teaching physics among ELL students. This finding is similar to past findings (Bani-Hamad & Abdullah 2019; Hod & Sagy, 2019). The results can be explained by the inherent differences between authentic learning, visualization, and traditional lecture and scientific inquiry, as well as the needs of ELL students. The use of authentic learning, visualization, and traditional lecture meets the needs of ELL better compared to scientific inquiry. The use of visualization is effective because teaching physics to ELL is attributed to the fact that pictures are understood in all languages

The effect of authentic learning can be explained by its concepts. For instance, the concept of collaboration meets the oral needs of ELL students. In particular, students with limited English proficiency are scared to speak out loud in English, particularly in front or presence of the entire class. This can be addressed by having students discuss in small groups, which helps them build their confidence. In addition, students can feel secure and more likely to collaborate with their friends in small groups.

The combination of authentic learning, visualization, and traditional lecture meets ELL students' needs better than scientific inquiry. Traditional methods also enable students to discuss questions with their teachers and among themselves. This is in line with Karakus's (2019) conclusion, which noted that the listening ability and speaking ability of ELL influence learning outcomes of subjects such as physics. In addition, the discussion enables ELL students to learn from their colleagues. During the scientific inquiry, most students will be on their own.

The study that the combination of authentic learning, visualization, and traditional lecture meets the needs of ELL better than scientific inquiry can be explained by the fact that the strategy enables students to solve the challenges that increase their comprehension. This is through the concept of real-world applicability of tasks where students are solving tasks and are provided with knowledge applicable outside the classroom.

The use of traditional lectures provides teachers with an opportunity to explain further and answer questions that students may have after using visualization and authentic learning. For instance, students may have questions from pictures and graphs they have seen. In this regard, students with limited English proficiency are provided with an opportunity to listen to their teachers, who design teaching lectures to meet their needs.

Students with limited English proficiency require support to develop their ability to use precise domain language to adequately describe and explain various physics concepts they learned in English. This support is better delivered when applying a combination of authentic learning, visualization, and traditional lecture compared to scientific inquiry.

Compared to scientific inquiry, the combination of authentic learning, visualization, and traditional lecture meets some of the enabling factors that support ELL when learning physics. For instance, Kalinowski et al. (2019) noted that learner's speaking ability is influenced by affective factors such as feedback from their fellow students listening skills. Feedback is one of the factors that influence language acquisition. Authentic learning, visualization, and traditional lecture provide an opportunity where a teacher can listen to a student speak when taking part in discussions and evaluate their ability. This opportunity is limited when students participate in scientific inquiry, where they spend significant time solving problems.

The findings showed that combining authentic learning, visualization, and traditional lecture encouraged daily life application of concepts and helped them integrate concepts with real-life better. This is reinforced by the study that the strategies stimulate the thinking of students. It can be explained by the fact that differentiated strategies increase interaction between students. Further, through discussions, students understand how they can apply the concepts to deliberate on various topics and how they relate to life. Given that ELLs have a challenge in understanding physics vocabulary, a combination of authentic learning, visualization, and traditional lecture allows them to comprehend concepts better than scientific inquiry. ELL students also prefer a variety of authentic learning, visualization, and traditional lecture because it enables them to remember important laws and equations and contextualize vocabularies better. Contextualization is essential in the understanding of scientific concepts where learners relate the content with real-life scenarios.

The survey showed that combining authentic learning, visualization, and traditional lecture enables students to manage foreign language anxiety better than scientific inquiry. The physics terms and vocabularies can create anxiety, especially for ELL students taking the subject for the first time. Khan, and Al-Mahrooqi (2015) established that ELL students were anxious about conversing with their peers and teachers in the classroom. The limited English proficiency and the level of anxiety from fear of a teacher were higher than the fear of evaluation from other students. Foreign language anxiety is a challenge because students fear communication and writing, unnecessarily consuming their cognitive capacity. A combination of authentic learning, visualization, and traditional lecture addresses this challenge, given it provides a chance to create a classroom environment that manages foreign language anxiety. For instance, the students with limited English proficiency can be encouraged to speak and offered constructive feedback, which can help them improve. Further through discussions and further expansions, the ELL students can gain confidence which can help them address foreign language proficiency.

The objective of this study was to determine how to offer support that could enable the learners to acquire the technical vocabulary necessary to comprehend key physics concepts. The results from the survey showed that authentic learning, visualization, and the traditional lecture were better teaching strategies than scientific inquiry for teaching physics among ELL students. This is because the combined methods enable ELL students to acquire the technical vocabulary necessary to comprehend key physics concepts. Students with limited English proficiency require support to develop their ability to use precise domain language to adequately describe and explain various physics concepts they learned in English. This support is better delivered when applying a combination of authentic learning, visualization, and traditional lecture compared to scientific inquiry

Compared to scientific inquiry, a combination of authentic learning, visualization, and traditional lecture meet some of the enabling factors that support ELL students in learning physics.

ELL students also prefer a combination of authentic learning, visualization, and traditional lecture because it enables them to remember important laws and equations and contextualize vocabularies better. The findings showed that the combination of authentic learning, visualization, and traditional lecture allows students to understand more compared to scientific inquiry. This is the case with regard to concepts of measurement and puzzling aspects of topics. Further combination of authentic learning, visualization, and traditional lecture encouraged daily life application of concepts and also helps them integrates concepts with real-life better. The survey also showed that combining authentic learning, visualization, and traditional lecture enables students to communicate the content knowledge, particularly in science concepts, better than scientific inquiry. This can be explained by the fact these strategies naturally entail listening and speaking where ELL can understand more.

VALUE

I was fortunate to have completed this project. I have grown personally and professionally throughout this entire experience. I have acquired more knowledge on teaching science to ELL and a more profound comprehension of various instructional strategies. One of the challenges for the project was developing questions that capture all aspects of teaching methods and the needs of ELL.

At the start of the project, I hoped to support ELL students in high school physics to help them comprehend instructions. I also sought to enhance learners' motivation and confidence by ensuring a better comprehension of physic concepts. Moreover, I intended to support learners in recording vocabulary relevant to physics content and assist strategies that work best to keep track of new terminologies to use as references in their discussions or writings. I have achieved all the objectives after completing the project and learning lessons along the way.

The survey results showed that a combination of authentic learning, visualization, and traditional lecture enables ELL students to address the challenge of foreign language anxiety better than scientific inquiry. In this regard, physics teachers have a responsibility in managing language anxiety among ELLs. This can be achieved by using teaching strategies that match the needs of ELL students and creating a supportive learning environment such that all students, regardless of their language proficiency levels, can express themselves. In addition, a learner's speaking ability is influenced by affective factors such as feedback from students and teachers and listening skills. In conclusion, teachers should offer differentiated instruction that is constructive and positive feedback to ELL students to help them meet their challenges.

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APPENDICES

APPENDIX A: QUESTIONNAIRE

This survey seeks to compare your opinion on the efficacy of two different teaching strategies. Kindly check the box that corresponds with your opinion on each method.

	Scientific Inquiry	Traditional Lecture
Which method enables you to understand more?		
Which method enables you to understand concepts of measurement?		
Which method enables you to understand puzzling aspects of topics?		
Which method enables you to encourages daily life application of concepts?		
Which method enables you to simulates your thinking?		
Which method enables you to integrates concepts with real-life better?		
Which method enables you to helps you remember important laws and equations?		
Which method enables you to learn independently?		
Which method enables you to think critically and logically?		
Which method enables you to discuss with the teacher?		
Which method enables you to contextualize vocabularies better?		
Which method enables you to communicate the content knowledge particularly in science concepts, better?		
Which method enables you to understand physics' specialized words better?		
Which method enables you to understand technical terms?		
Which method enables you to understand non-technical terms?		

	Scientific Inquiry	Traditional Lecture
Which method meets the needs of your reading challenges better?		
Which method enables you to manage foreign language anxiety?		
Which method enables you to discuss and learn from other students?		
Which method enables you to attain written English proficiency?		
Which method enables you to attain spoken English written proficiency?		
Which method enables you to improve your language accent?		