Development of self-efficacy in high school students through soil analysis in the protected natural area "Estero El Soldado"

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Abstracts

Teaching various scientific disciplines involves both hands-on and theoretical methods aimed at sparking students' curiosity in learning concepts. Students enhance their comprehension by actively engaging in direct activities rather than solely relying on explanations provided by teachers. The development of a research project carried out by 12th grade students during the semester allowed them to develop scientific or technological research to understand nature and act on it. The research project involved taking soil samples of natural protected area "Estero El Soldado" and analyzing it using a microscope, increasing student's self-efficacy using the microscope. Self-efficacy was measured before and after the proposed research project using the General Self-Efficacy Scale instrument (Baessler and Schwarzer, 1996), which consists of 10 items and measures a person's perception when facing a variety of stressful situations. The participation of 43 12th grade students was analyzed. After the completion of the research project students, the results from the pre-test ($M = 66.89$, $SD = 19.52$) and post-test ($M = 80.34$, $SD = 19.84$) self-efficacy evaluation indicate that carrying out the research project resulted in an improvement in self-efficacy, $t(84) = 2.01$, $p = 0.0008$. We can conclude that integrating hands-on research projects like soil analysis using different laboratory equipment boosts 12th-grade students' scientific self-efficacy, as evidenced by improved scores on the General Self-Efficacy Scale. These findings underscore the value of experiential learning in nurturing both scientific skills and confidence in students.

Keywords: Education innovation, hands-on teaching, self-efficacy

Introduction

The scientific competence is sought to be developed in various science courses through the development of a research project carried out throughout the semester, which allows students to develop scientific or technological research to understand nature and act on it with a sustainable

perspective and ethical criteria. The development of this competence is evaluated through a core activity, and we have noticed that the activities that are traditionally carried out do not have the expected impact on the students. This study focuses on the development of self-efficacy through a hands-on project that involves microscopic analysis of soil samples from "Estero El Soldado" in 12th grade students.

Background

The teaching of different areas of science requires practical and theoretical processes that promote in students an interest in learning new concepts, and the development of the understanding of the content through their own direct activity instead of obtaining it from the explanation previously organized by other teachers [1]. Hands-on-approach is a method of instruction where students are guided to gain knowledge by experience [2]. Through hands-on-approach, students are able to engage in real life illustrations and observe the effects of changes in different variables [2].

Self-efficacy refers to how confident people are in their judgment of their own capacity to handle tasks, challenges, and contexts and is derived from the social cognitive theory [3]. Self-efficacy, according to Bandura, can be defined as the perceptions of individuals as they judge their own capabilities to perform adequately in given tasks [3].

It is believed that there are at least four sources that influence self-efficacy; verbal persuasion, emotional arousal, vicarious experience, and mastery experience, which is the most influenced one [4]. Hence the importance of hands-on experiences for students.

If an individual feels that the task is familiar, he/she usually has a high level of self-efficacy [5]. Also, learners with lower levels of self-efficacy tend to disengage from the designated learning tasks and assignments they believe to be beyond their capabilities [6]. Other studies have consistently indicated that learners with higher levels of self-efficacy exert greater effort to successfully complete academic tasks. [7][8]. Pajares and Schunk proposed that general self-efficacy could be assessed as domain-specific or task-specific. In this study, self-efficacy is evaluated as task-specific for the use of microscope [9].

It should also be noted that self-efficacy has been identified as an outstanding antecedent related to classroom engagement and learning [10]. Previous studies mainly suggested that students who have stronger levels of learning self-efficacy will be motivated to be cognitively engaged in establishing self-regulatory strategies to improve cognitive competency, and thereby generate satisfactory learning performance in the classroom [11][12].

Students' deep engagement in science has been regarded as a significant antecedent in contributing positive outcomes and performance [13]. Furthermore, students' self-efficacy has been found to be an influencing contributor and to be closely associated with their engagement in science learning [14]. Schunk and Pajares also argue that individuals must have self-confidence in the relevant field before using their skills effectively [15].

Having students perform this project in teams can prove to be more beneficial than if they were working on their own. According to Kiran and Sungur, students do not judge their level of capabilities just by interpreting personal performance accomplishments. Having the vicarious experience of observing others perform a task can also help students form their efficacy beliefs [16]. This agrees with what Schunk asserts, that the act of observing others succeeding in a task enhances the observers' self-efficacy and leads them to make an effort in similar tasks because they start to think that that if others can accomplish it, so can they [17].

A fundamental methodological task of teaching is to set up the conditions for students' research activities in the natural sciences, then move on to teach them the fundamentals of the physics, chemical, and biological sciences [18]. It should be pointed out that the knowledge and skills acquired by students in independent research activities are universal and can be used to study any subject and meet various educational needs [19]. Therefore, integration of laboratory activities with theory classes has been found to be positively related to their achievement [20].

Regarding the soil analysis from the protected natural area "Estero El Soldado", utilizing everyday life-related scenarios as an approach enables the development of interdisciplinary core ideas, plus their applicability to everyday life, which potentially increases the relevance of science learning for students [21].

Coastal lagoons are recognized as sites of ecological and socioeconomic importance, so it is important to generate basic knowledge to guide decision-making for their use, management, and preservation [22]. "Estero El Soldado", is located in the state of Sonora, which is a protected natural area in the state category of "Zone Subject to Ecological Conservation" [23]. The analysis of both soil, water and biodiversity of "Estero El Soldado" helps to understand the biogeochemical processes and shows the importance of monitoring them throughout the annual cycle, as well as in long-term periods [24].

Motivation

Currently, we find students in the classroom who, after the pandemic, are more aware of the need to get involved in activities to learn more easily [25]. They demand activities that allow them to develop skills that they did not develop during the pandemic. Given that, in educational settings, students who hold strong self-efficacy beliefs in learning a given task and performing it successfully are likely to engage in the task, while less self-efficacious students are likely to avoid it [26], increasing their science self-efficacy through the use of the microscope will benefit students in their development of scientific skills.

These skills, aimed at improving life in the 21st century, seek practices that enable learners to apply what they learn in real-life situations [27].

Objective

To develop self-efficacy of 12th grade science course students by analyzing soil samples from the protected natural area "*Estero El Soldado*" using microscopy techniques and by the development of proposals for improvement and solutions to problems in the area.

Methods

Participants

In total, 43 12th grade students from PrepaTec Campus Sonora Norte, were invited to participate in this study. All students were enrolled in a scientific research elective course: "21st Century Science and Technology". The students were divided into three school groups. Information and sample size can be observed in Table 1.

Table 1. Participant information

Class	School group	Sample Size
21st Century Science and Technology	1	14
21st Century Science and Technology	2	12
21st Century Science and Technology	3	17
Total		43

Instruments

For this study, "self-efficacy" on the use of a microscope was analyzed. For the analysis of self-efficacy, the Baessler and Schwarzer General Self-Efficacy Scale instrument in its Spanish version, which has been validated by Cid, Orellana and Barriga in 2010 [28], was used. The General Self-Efficacy Scale instrument consists of 10 items and measures a person's perception when facing a variety of stressful situations. The student must indicate whether he or she agrees with the statements, which range from "totally disagree" (0) to "totally agree" (3) [29].

Table 2 shows the items on the questionnaires that were applied in its Spanish version.

Table 2. Items on the Self-efficacy Questionnaire applied

Item
1. Puedo encontrar la manera de obtener lo que quiero aunque alguien se oponga.
2. Puedo resolver problemas difíciles si me esfuerzo lo suficiente.
3. Me es fácil persistir en lo que me he propuesto hasta llegar a alcanzar mis metas
4. Tengo confianza en que podría manejar eficazmente acontecimientos inesperados.
5. Gracias a mis cualidades y recursos puedo superar situaciones imprevistas.
6. Cuando me encuentro en dificultades puedo permanecer tranquilo(a) porque cuento con las habilidades necesarias para manejar situaciones difíciles
7. Venga lo que venga, por lo general soy capaz de manejarlo.
8. Puedo resolver la mayoría de los problemas si me esfuerzo lo necesario.
9. Si me encuentro en una situación difícil, generalmente se me ocurre qué debo hacer.
10. Al tener que hacer frente a un problema, generalmente se me ocurren varias alternativas de cómo resolverlo.

Administration and Collection

Given that the students are minors, each of the students was given a consent form to be signed by them and their parents for participation in the study. Students were assured that all the personal information and scores obtained during the exercise were for a singular purpose of the study and therefore were treated with the utmost confidentiality.

The General Self-Efficacy Scale questionnaire was applied to students during class after giving them instructions on how to answer questions using the Likert scale. The questionnaire was applied at the beginning of the semester (pre-test) before the research project was carried out.

The same questionnaire was applied at the end of the semester (post-test) after completion of the laboratory practices and research project.

For the self-efficacy questionnaire, students were provided with different scenarios particularly for difficulties that might present during the use of a microscope. Based on those scenarios they answered the pre-test and post-test.

Project

To connect the learning of science content with 21st century science skills and the use of microscope for soil analysis, three laboratory practices were carried out with students. Given that the group of students had never used a microscope in real life because of the pandemic, the first laboratory practice was an introduction to the microscope for students to identify its parts and learn its use. The second practice was an analysis of stem and roots for students to visualize and identify cells. And the third and final practice involved previous research about "Estero El Soldado" and the analysis of soil samples taken from the coastal lagoon.

Data Analysis

The data gathered from the pre-test and post-test were analyzed using both descriptive and inferential statistical tools. The answers for the items on the Likert scale were normalized to a 100 scale. Mean and standard deviation were employed, as well as a 2-tailed t-Test to obtain statistical significance.

Results

Table 2 shows various descriptive statistics of the self-efficacy pre-test after normalization of the Likert scale. The mean for all items on the self-efficacy scale was 66.9 with a standard deviation of 19.53.

As seen on Table 3, the mean for the self-efficacy scale post-test showed an increase to 80.35 with a standard deviation of 19.85.

Table 2. Self-efficacy descriptive statistics

Pre-test	
Mean	66.90
Median	70.00
Mode	70.00
Standard Deviation	19.53
Range	66.67
Minimum	33.33
Maximum	100.00
Sum	2876.67

Table 3. Self-efficacy descriptive statistics

Post-test	
Mean	80.35
Median	85.00
Mode	100.00

Standard Deviation	19.85
Range	85.00
Minimum	15.00
Maximum	100.00
Sum	3455.00

As shown in Table 4, a two-tailed t-Test was carried out, producing a $t(84) = 2.01$, with $p = 0.0008$. This result suggests that the students had a significant improvement in their self-efficacy perception after participating in the research project and practicing their skills using the microscope.

Table 4. Self-efficacy t-Test: Paired Two Sample for Means

	PRE	POST
Mean	66.89922	80.34884
Variance	381.2938	393.8569
Observations	43	43
Pearson Correlation	0.215338	
Hypothesized Mean Difference	0	
df	42	
t Stat	-3.57603	
P(T<=t) two-tail	0.000894	
t Critical two-tail	2.018082	

Discussion

Results from this study show that the self-efficacy of students using a microscope (post-test mean score 80.34) exposed to a hands-on strategy showed a statistically significant improvement from before they caried out their research and lab practices (pre-test mean score 66.89). This shows that hands-on teaching strategies, particularly in use of microscope, improves self-efficacy perception of students by having them participate and practice during laboratory activities.

These findings agree with those of Salami and Egiethua, where they mention learning becomes more interesting when it is through actions and experiences [30]. In their study, they found out that hands-on as an instructional strategy encourages learners' active participation in the teaching-learning processes. Okono, also mentioned that the use of experiments as a teaching methodology for Physics in secondary school is crucial for successful concept delivery by the subject teachers and concept mastery by the students [31].

Conclusions

It is clearly seen from the result of the analysis carried out in this study that hands-on teaching strategies using real-life scenarios made it possible for students to gain science self-efficacy.

The authors encourage other teachers and education institutions to incorporate more hands-on and experiment-based teaching strategies and approaches for all subjects but particularly science.

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