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The relationships between learners' academic achievement due to the use of constructivist methods in physical science and their self-esteem in zambian secondary schools

Eric Bahufite [a,*], Sophie Kasonde-Ng'andu [b], Akakandelwa Akakandelwa [b]

[a] *Educational Psychology; School of Education; University of Zambia Zambia*
[b] *University of Zambia, School of Education Zambia*

ABSTRACT

The effects of the constructivist learning approach on various aspects of learners' development, such as academic achievement, have been extensively documented. However, there is limited or conflicting knowledge regarding the relationship between academic performance resulting from this approach and learners' self-esteem. Consequently, this study aimed to investigate the correlation between academic achievement, as a result of employing constructivist learning approaches in teaching physical science, and learners' self-esteem.

To achieve this goal, a quasi-experimental research design incorporating mixed methodology was employed, involving 376 grade 10 students and 10 physics teachers from five secondary schools in Zambia's Lusaka province. Data collection utilized a combination of a semi-structured interview guide, Rosenberg's Self-Esteem Scale, and standard science achievement tests. The study revealed a strong interdependency between learners' self-esteem and academic achievement. Each of these factors influences the other, with intrinsic motivation and metacognitive knowledge serving as crucial bridges. Furthermore, the dominance of social interactions and personal experience sharing, inherent in the constructivist learning approach, was found to enhance the fundamental variables of academic achievement and self-esteem, namely motivation and metacognitive knowledge. To gain a deeper understanding, further research should be conducted with a particular emphasis on the impact of learners' intrinsic motivation, critical thinking, cognitive growth, and development on their academic achievement and self-esteem. Additionally, it is recommended that school administrations promote the use of constructivist learning approaches among teachers through Continued Professional Development (CPD) programs.

1. Introduction

Scholars assert that a comprehensive education, particularly in the realm of science, can yield substantial benefits for students' personal growth and the advancement of societies and nations (Kaygin, Yilmaz, & Semerci, 2017; Papastephanou, 2013). In Zambia, there has been a noteworthy emphasis on physical science within the school curriculum with the intention of fulfilling national development objectives (Ministry of General Education (MoGE), 2018).

Regrettably, Zambia has consistently struggled with underwhelming performance in this subject at the Grade 12 level, despite acknowledging the significance of scientific disciplines in the nation's progress (Kafata & Mbetwa, 2016; Ministry of Education, Science, Vocational Training and Early Education, 2013). Evidently, according to Table 1, the pass rates for physical science in the years 2014, 2015, 2016, 2017, and 2018 stood at 17.79%, 16.05%, 32.83%, 43.58%, and 34.32%, respectively, with a distinction rate of 5.93% (Zambia National Education Coalition (ZANEC), 2019; Ministry of General Education, 2016; 2018; Phiri, 2019).

Nevertheless, the poor record performance in science at the secondary education level is not only a current concern. As noted by Kafata and Mbetwa (2016), it has been a recurring issue within the Zambian educational system since Independence in 1964.

One of the factors responsible for this underperformance is the teachers' heavy reliance on traditional methods, which are guided by essentialism and perennialism (Bhutto, Qazi, & Rawat, 2018; Stern,

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Table 1
Pass rate percent of Physical science over recent 5 consecutive years at the end of Grade 12 National Examinations in Zambia.

Academic Year	2014	2015	2016	2017	2018
The pass rate in Physical science	17.79%,	16.05%	32.83%,	43.58%	34.32%

Kampourakis, Huneault, Silveira, & Müller, 2018). Typically, teachers resort to these methods due to examination pressure, aiming to ensure their students pass the required exams set by educational regulators. Additionally, the influence of the Western World on the curriculum content has compelled teachers to maintain the status quo, leaving limited room for students' creative thinking.

Despite their dominance, traditional approaches have faced criticism for being authoritarian, short-sighted, and impeding students' ability to reach their full potential (Alam, 2013). Zirhlioğlu and Yayla (2016) assert that the prevalence of these methods in the education system negatively affects students' self-esteem, which in turn impacts their academic achievement. Extensive research has shown a close association between these two psychological elements in students (Hassan, Jami, & Aqeel, 2016). Thus, students' future performance can be inferred from their level of self-esteem, which is influenced by the teaching-learning methods employed during their education (Hassan et al., 2016; Zoabi, 2012). Therefore, the adoption of constructivist methods is suggested as a preferable alternative. The prominence of constructivist methods is believed to not only enhance academic performance but also foster the normal development of students' self-esteem (Suneetha, 2014). Furthermore, the impact of these learning methods and academic achievement extends beyond the present and has the potential to shape students' future endeavors, especially when considered alongside their effects on self-esteem (Hassan et al., 2016).

However, the effectiveness of using these methods, specifically in the field of science, has not been thoroughly verified in the Zambian education system. Therefore, this study aims to comprehensively investigate the correlation between implementing constructivist learning methods and the resulting outcomes of learners' academic performance and changes in their self-esteem.

2. Theoretical background

The primary focus of this study was on examining the relationships between learners' self-esteem and their academic performance in relation to the use of constructivist learning-teaching methods. Self-esteem refers to an individual's general self-assessment, leading to their evaluation of themselves as either good or bad (Santrock, 2017; Woolfolk, 2016). This aspect of one's personality can be categorized as either high or low and may vary over a lifetime, oscillating between negative and positive self-perceptions depending on life circumstances (Santrock, 2017; Schunk et al., 2014; Woolfolk, 2016).

Low self-esteem, as described by Mruk (2013), is often associated with various difficulties, including health and academic challenges, while high self-esteem is linked to success, good mental health, and a harmonious life within society, both in the present and in the future (Abdel-Khalek, 2016). This view is supported by Woolfolk (2016), who explains, based on prior research findings, that the level and nature of self-esteem developed at a young age determine the type of relationships formed later in life, including during adulthood. Schools can provide a suitable environment for fostering this development, as they help children develop cognitive and affective skills beyond their familial contexts.

In fact, children go through their developmental processes in school, where teachers' decisions regarding treatment and teaching methods significantly contribute to learners' personality development (Mruk, 2013). One such method is the constructivist approach, characterized by a friendly relationship between teachers and learners, as well as among learners themselves. It has been observed that teachers' behaviors towards their students can result in positive or negative self-perceptions and attitudes towards academic work and the learning environment. Continuous forms of treatment such as nagging, lack of tolerance, and lack of empathy, which are associated with traditional teaching methods, can permanently impact learners' emotional well-being, negatively affecting their self-esteem and performance, particularly for those who experience similar treatment at home (Zirhlioğlu & Yayla, 2016; Bahufite, Kasonde-Ng'Andu, & Akakandelwa, 2022; Naeem, Sharif, Sharif, & Seemi, 2023). On the other hand, when learners are permitted to collaborate in groups and are given the freedom and equal opportunity to participate in the learning-teaching process, they exhibit a profound sense of belonging, experience a strong connection to the educational institution, and possess a high level of self-assurance (Bahufite, 2015).

Nevertheless, it is challenging to discuss self-esteem and academic achievement without acknowledging the underlying factors, such as intrinsic motivation (Mikail, Hazleena, Harun, & Normah, 2017; Zoabi, 2012). When combined with cognitive development, intrinsic motivation facilitates learners' performance, further bolstered by the utilization of constructivist learning approaches (Mruk, 2013; Nawaz, 2012; Qarareh, 2016). Bozgun and Akin-Kosterelioglu (2023) propose that the two educational outcomes, self-esteem and academic achievement, are also interconnected through the learners' metacognitive knowledge. Metacognitive knowledge refers to learners' understanding or awareness of the extent of their knowledge and cognitive abilities.

2.1. Metacognitive knowledge

Metacognition pertains to individuals' capacity to transcend simple or ordinary cognition and engage in introspection regarding their own cognitive processes and the effectiveness of these processes in solving everyday problems (Ryum et al., 2017). It encompasses metacognitive knowledge, which refers to learners' awareness of their own knowledge, as well as metacognitive regulation, which involves learners' efforts to enhance their learning and memory through the application of cognitive strategies such as planning, monitoring, and evaluation (Mikail et al., 2017; Muijs & Bokhove, 2020).

Metacognition can be effective in aiding individuals in making sound decisions and addressing problems, thus leading to improved academic achievement (Muijs & Bokhove, 2020). Conversely, insufficient development of this skill can result in individuals with low self-esteem relying on others due to a lack of confidence in their own cognitive abilities (Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2020). Consequently, individuals may disregard their own experiences and instead depend on others' opinions, even for basic problem-solving. This state of confusion often leads to poor academic performance among students.

On the contrary, the proper development of learners' metacognitive knowledge can compensate for this deficiency by equipping them with the ability to objectively assess their knowledge and thinking abilities, and utilize this assessment to improve their academic achievement (Muijs & Bokhove, 2020). It is important to note that this capacity is derived from the relationship between metacognitive knowledge and metamemory, which enables individuals to understand the quantity and quality of their memory and develop cognitive strategies to enhance their memory capacity and performance (Muijs & Bokhove, 2020). Additionally, it is worth noting that this achievement can be facilitated through the implementation of constructivist learning methods (Langdon et al., 2019), which have been proven to enhance learners' metacognitive knowledge.

Various studies have established a correlation between metacognitive knowledge and learners' academic performance, as well as their self-esteem (Langdon et al., 2019; Mikail et al., 2017). Additionally, Acosta-Gonzaga and Ramirez-Arellano (2021, pp. 1–12) observed that certain components of self-esteem, such as emotions, impact

learners' intrinsic motivation. This finding has prompted further exploration of metacognitive methods, leading to enhanced academic achievement. The interconnectedness of these factors underscores the significance of investigating this subject further in future research.

2.2. Studies on the effects of learners' self-esteem on the academic performance

Academic performance stands as one of the primary indicators of the quality of education imparted by teachers and relies on various factors. Apart from teaching methods, other contributors to this performance encompass learners' self-esteem levels, among others (Abdel-Khalek, 2016). Consequently, teachers can enhance their students' performance by fostering their self-esteem. This objective can be accomplished by identifying the areas of competence that hold significant value to the learners, subsequently aiding them in improving their performance in those specific areas (Santrock, 2017; Woolfolk, 2016). By doing so, learners' self-esteem is likely to experience significant growth when they succeed in areas that hold substantial importance to them. Likewise, having a positive self-image enhances students' likelihood of excelling academically. An example illustrating the repercussions of sex-role stereotypes on girls' self-esteem is provided by Igbo, Onu, and Obiyo (2015), wherein such stereotypes are condemned for undermining girls' academic performance and limiting their opportunities for a prosperous future compared to their male peers. Nonetheless, in a constructivist learning environment, Bahufite, Kasonde-Ng'Andu, and Akakandelwa's study (2022) discounts the impact of gender on learners' self-esteem levels.

Additionally, in alignment with the relationship between self-esteem and academic performance, Abdel-Khalek (2016) notes that individuals with low self-esteem exhibit diminished confidence, resulting in unnecessary errors and difficulties fitting into society. However, in agreement with Erikson (1980), Woolfolk (2016) suggests that for self-esteem to translate into tangible accomplishments within educational institutions, students should be presented with challenging problem-solving tasks that simultaneously elevate both self-esteem and performance. Nevertheless, she further argues that the level of self-esteem alone does not guarantee personal satisfaction, happiness, or harmonious coexistence within society, particularly if the development of this aspect is not conducted genuinely. In light of this, inspired by the ideals of the self-esteem movement, Woolfolk (2016) recommends that schools take the initiative to foster self-esteem by employing teaching methods that promote critical thinking, experiential learning, and problem-based approaches, emphasizing fair teamwork rather than competition. In adopting this social constructivist approach to learning, genuine and comprehensive development of learners' self-esteem can be effectively safeguarded.

Furthermore, the scholarly discourse and inquiry regarding the correlation between self-esteem and academic achievement have revealed that this connection is not unidirectional under most circumstances. Ugwuanyi, Okeke, and Asomugha (2020) assert that an enhancement in self-esteem leads to an augmentation in academic achievement, thus suggesting that low self-esteem could similarly result in subpar academic performance. Essentially, in order to enhance academic performance, it is imperative to address the self-esteem of learners as a primary concern. This viewpoint is echoed by Hassan et al. (2016), who contend that self-esteem stands as one of the most reliable indicators of learners' future academic success. Furthermore, in their research conducted in Pakistan, they discovered a significant correlation between self-esteem and academic achievement among both truant and punctual students (Hassan et al., 2016). However, this association between academic performance and self-esteem was found to be statistically insignificant among adolescent students, and no disparity in self-esteem was discerned between truant and punctual students, thereby rendering generalization unfeasible.

Nevertheless, self-esteem should not be comprehended solely from a broad perspective; rather, it may be partial and, consequently, the resulting performance may stem from specific inherent factors, such as motivation or others (which it engenders). In this context, Zoabi's (2012) findings from research conducted in Israel demonstrated that lower academic performance among minority students was attributed to their minimal motivation to learn, which principally resulted from low self-esteem, further impairing their participation in tertiary educational institutions. Similarly, Zuković and Stojadinović's (2021) study revealed that teachers tended to affirm boys more frequently than girls through praise and attention. This tendency was assumed to detach girls from the learning-teaching process as a whole, ultimately leading to the gradual development of low self-esteem. Consequently, this would have adverse effects on their academic performance, as they would neither exert sufficient effort to succeed nor strive for higher academic aspirations.

Thus far, the diverse body of work reviewed sheds additional light on the relationship between self-esteem and academic achievement, albeit explored through different methodologies and in distinct environmental contexts. Therefore, it would be highly advantageous to further investigate and elucidate this relationship specifically within the purview of teaching science subjects at the secondary education level.

2.3. Action of constructivist learning methods on both self-esteem and academic performance

In an effort to further establish the relationship between the use of constructivist learning methods in classrooms and learners' self-esteem and performance, several studies were conducted in different locations. Karali and Aydemir (2018) examined the effect of the cooperative learning method and observed that it was more effective in mathematics compared to traditional methods in terms of learners' academic performance in Turkish schools. The authors attributed this success to the prevailing social environment in the method, which contributed to an increased sense of self-worth and self-image among learners. They found that learners better understood themselves through interactions and opportunities to help others and learn from them. However, a study by Wilson and Zoellner (2016) on the effectiveness of constructivist-based science camps in the Southern United States found no impact of this learning strategy on learners' self-concept, particularly in homogeneous and highly skilled groups. Nevertheless, they noted that learners' scientific knowledge of the topics and understanding of the nature of science improved.

In another study conducted in Canada by Joy and Murphy (2011) on primary school children, the use of social constructivism in the classroom not only enhanced learning outcomes but also fostered a sense of belonging to a real human community, thus contributing to emotional development. However, this outcome primarily affected the affective aspect of learners rather than their cognitive performance.

Nonetheless, the practice of teaching one another, as encouraged by constructivist learning methods, was found to enhance long-term memory and enrich the content material taught, leading to higher academic achievement (Tran & Lewis, 2012). Furthermore, the use of constructivist learning methods was found to enhance the development of multiple life skills, a sense of responsibility, and learners' confidence for future success. This aspect of high self-esteem was particularly evident in Zambian schools (Bahufite, 2015), as shown by a study conducted in Lusaka's secondary schools. In this context, learners were no longer solely focused on their own performance but also on the performance of their peers. Additionally, the use of new cognitive strategies in constructivist learning replaces the competitive nature often found in traditional schools and classrooms. As a result, learners are encouraged to develop both collaboratively and individually through the application of these methods (Tran & Lewis, 2012; Bahufite, Kasonde-Ng'Andu & Akakandelwa, 2022).

Based on the literature reviewed, it can be concluded that the choice of an appropriate learning-teaching method in the classroom can assist teachers in fostering a positive self-image among learners through

creating an environment where they feel a strong sense of belonging. Although the findings from various studies may differ, one clear observation is that the utilization of constructivist learning methods has the potential to enhance learners' academic performance and self-esteem, either individually or concurrently. However, the precise relationship between the implementation of different constructivist methods in the teaching and learning process of physical science and the subsequent impact on learners' self-esteem and performance in Zambian Secondary Schools remains to be fully elucidated.

3. Methodology

The nature of this study necessitates the adoption of an experimental research design, which according to Kivunja and Kuyini (2017), is well-suited to both positivist and pragmatic research paradigms. Pruzan (2016) defines experiments as *"an active (manipulative and/or comparative) intervention to test hypotheses and develop causal explanations"* (p161). Experimental designs, such as the one employed in this study, use experiments to compare variables and verify hypotheses within the study's population (Sahu, 2013). In this regard, the study opted to use the informal experimental research design, which included two assessments conducted before and after the intervention (teaching physical science using the constructivist learning approach). The first assessment involved a self-esteem test using Rosenberg's Self-Esteem Scale, while the second was a standard achievement test for physics. Since all participants in the sample received the same pre- and post-testing circumstances and the same treatments, a control group was deemed unnecessary.

Additionally, the study utilized a mixed methodology that combined quantitative and qualitative approaches in line with the pragmatic research paradigm. Mertens (2015) supports the decision to employ methodology triangulation, as it broadens the scope of data collection and analysis, enhances the credibility of research findings, and provides insightful conclusions for different audiences. The quantitative component of this methodology was used to gather, evaluate, and interpret data on students' academic achievement and self-esteem resulting from the use of constructivist learning-teaching methods. Meanwhile, the qualitative component was utilized to collect and analyze information on teachers' experiences in relation to their choice and usage of constructivist or traditional teaching approaches.

3.1. Research participants

The research population consisted of 16,900 Grade 10 students and their physical science teachers in Lusaka Province. To assess the effectiveness of the Constructivist Learning Model (CLM), a pre-test was administered at the start of the term, and a post-test was conducted at the end of the term. A total of 376 students were selected to complete both standardized achievement assessments. Additionally, ten physics teachers were purposively chosen to participate in the study. These teachers were responsible for teaching the classes involved in the experiment. Along with implementing the new strategy in the learning-teaching process, they also responded to interview questions.

3.2. Procedure

Various data collection instruments were used to achieve the study objective, including an interview guide for teachers, Rosenberg's Self-Esteem Scale, and standard physics achievement tests for pupils. The tests were conducted in two sets, the pre- and post-treatment tests, and administered to 376 grade 10 pupils from five secondary schools in Lusaka province, Zambia. The research design employed was EG: O_1O_2 X O_1O_2, where self-esteem assessments (O_1) and physics achievement tests (O_2) were conducted before and after the treatment (X).

To assess the academic performance of grade 10 students before and after implementing teaching methods based on the Constructivist

Learning Model, two Standard Achievement Tests were used. The pre-treatment test covered topics of physical measurements, such as length, time, mass, volume, weight, and density, which were part of the grade 10 physics syllabus. The first test aimed to encompass these topics, while the second test focused on Vector and Scalar Quantities, Motion in One Direction, and the Concept of Force, complementing the initial assessment.

Test items were selected based on educational objectives and the relative weights were determined according to Bloom's Taxonomy of Educational Objectives, which includes recalling, understanding, applying, and advanced cognitive operation.

Experts reviewed the items to ensure their content validity. The reliability of the achievement tests was evaluated through a pilot test-retest approach, with the exams given twice, two weeks apart, to a sample of 30 grade 10 students from a school within the target population. The correlation coefficient between the test and retest results was strong, indicating high consistency and stability (+0.818 for the pre-test, +0.659 for the post-test).

3.3. Data analysis

The qualitative data from the study underwent thematic evaluation in order to assess the teachers' perspectives on the application of constructivist teaching techniques in the field of physical sciences. Qualitative content analysis was utilized to classify the transcribed interview responses based on the emerging themes. By employing this approach, the researcher was able to uncover the overarching themes and underlying meanings within the collected data. This methodology was employed to derive value and significance from the information obtained through the interviews with the teachers. Conversely, the quantitative data gathered during the pilot and final stages of the study consisted of results from a standardized physics achievement test. This data was utilized to examine and validate predictions concerning the correlation between students' academic success in physics and their levels of self-esteem.

To achieve this, frequencies were computed using the Statistical Package for Social Sciences (SPSS). Moreover, the data analysis incorporated the implementation of various statistical tests, including the Independent Sample Kruskal-Wallis Test, the Related Samples Wilcoxon Signed Rank Test, the Independent-Samples Mann-Whitney *U* Test, Spearman correlation, and Z-test.

4. Results

This study conducted an analysis utilizing both qualitative and quantitative data. The qualitative data served to elucidate the teachers' critical perspectives on the implementation of constructivist teaching techniques in the realm of physical science education, as well as provide insight into their preferred instructional methods. As for the quantitative data, it was obtained through two distinct phases of data collection: the pre-treatment and post-treatment stages. The administration of tests during each of these phases allowed for an examination of the correlation between students' performance in the physics test and their self-esteem. This analysis aimed to ascertain the nature and degree of the relationship between academic achievement before and after implementing the treatment. Subsequently, the combined findings from both tests formed the foundation for evaluating the null hypothesis, which posited that *"There is no significant relationship between the academic performance of students in physics and their levels of self-esteem."*

4.1. Findings from teachers

In order to comprehensively explore the constructivist learning strategy, interviews were conducted with the study participants, who were physical science teachers. They were queried on their perspectives regarding the potential utilization of this approach. The majority of the

respondents exhibited a highly favorable outlook. However, those who expressed reservations believed that students may not possess the capability to learn independently. These individuals often criticized the intricate nature of the subject matter (physics) or the students' work attitude. Additionally, situational obstacles that impeded self-directed learning were mentioned. One person voiced their argument on this particular matter:

In subjects such as physics, there is a large extent to which the pupils cannot learn on their own. Look, for example, a demonstration of Hooke's Law or introducing the graphical representation of the motion; these are just two examples where the complexity of the topics as well as the involvement of calculations might not allow us to let pupils be on their own. There is always a need for the teacher's involvement in a demonstration for the pupils to fully understand some topics. (Participant #5).

Another one added:

At times, pupils' attitude towards work or school work is usually not that good. Some are not mature enough and we have to push them most of the time to do the school work, and this might result in limitation of our effort to engage them to work independently (Participant #2)

The complexity of the subject matter, coupled with the students' attitudes towards their own learning, were identified as significant barriers to the effective implementation of constructivist teaching methods in the context of physical science education. Consequently, teachers often felt compelled to utilize teacher-centered approaches in order to facilitate the delivery of their lessons in a more comfortable manner.

4.2. Pre-treatment tests findings

The initial assessment aimed at examining the connection between self-esteem and academic achievement was conducted prior to implementing the constructivist learning model. Its purpose was to determine if there existed a notable distinction between the two variables. Comprehensively, the obtained results indicated a significant and positive Spearman correlation of r (374) = +0.135, p = .004, at α = .01, signifying that academic performance and self-esteem were significantly associated before the implementation of the instructional intervention. Consequently, it was necessary to execute a comparable evaluation following the application of the constructivist learning model in the teaching of physics.

4.3. Post-treatment tests findings

The post-treatment test was conducted after a four-month period of instruction using the constructivist learning model. All 376 students participated in both physics achievement tests and self-esteem tests. The results revealed a significantly positive correlation of r (374) = +0.215, p = .001, indicating a moderate positive relationship between students' performance in physics and their self-esteem after the experiment.

To further evaluate the connection between students' academic performance and self-esteem levels, the pre-treatment and post-treatment test results were compared. This analysis aimed to provide a comprehensive and conclusive understanding of the impact of the constructivist learning model on the relationship between students' academic achievement and self-esteem levels.

4.4. Pre-post-treatment tests results

After calculating the correlation prior to and subsequent to the implementation of the constructivist learning model, a comparison was made between the two outcomes. The initial and prompt conclusion drawn from this comparison was that the post-treatment test yielded a positive correlation coefficient of r = +0.215, surpassing the pre-treatment test result of r = +0.135. This indicates that the

relationship between academic performance in physics and self-esteem became stronger after the treatment compared to before. This emphasized the significance of employing the constructivist learning model in influencing this correlation discrepancy.

However, in order to bolster this observation, it was necessary to complement it with a statistical test examining the influence of academic performance in physics on the learners' self-esteem. Consequently, due to the non-normal distribution of the test results, a non-parametric, Related Samples Wilcoxon Signed Rank Test was deemed a superior choice for this purpose, commencing with the pre-test outcomes.

The findings of the Related Samples Wilcoxon Signed Rank Test, as displayed in Table 2, established a significant influence of academic performance in physics on the learner's level of self-esteem prior to treatment, with p < .001. Nevertheless, it is important to note that this test was conducted solely based on the raw self-esteem data, without taking into account the varying levels of self-esteem among the students. In an effort to address this limitation, the Independent Sample Kruskal-Wallis Test was conducted, and the results are outlined in Table 3.

The test results, indicated by p = .126, did not provide sufficient evidence to establish any significant distinction between the pre-treatment physics test scores and the levels of self-esteem among the learners. Consequently, it can be inferred that the performance of the learners in the pre-treatment physics test did not have a noteworthy impact on their levels of self-esteem, regardless of whether their self-esteem was classified as high, average, or low. To further validate this finding, the Independent-Samples Kruskal-Wallis Test was conducted after implementing the constructivist learning model. Its purpose was to assess the influence of physics performance on the level of self-esteem among the students.

The observations presented in Table 4 indicate that the performance in the post-treatment physics test had a direct influence on the students' self-esteem levels. This suggests that there is a causal relationship between the learners' academic performance and their level of self-esteem after intervention.

However, it was important to further investigate whether other factors, such as age and gender, could be contributing to these observed relationships. To examine this, the Independent-Samples Mann-Whitney U Test was conducted. The results showed that gender did not have a significant impact on the physics achievement test scores, both in the pre- and post-treatment tests (p = .464 and p = .555, respectively, at α = 0.05).

Furthermore, the Independent-Samples Median Test was used to assess the influence of age on the students' achievement in the pre- and post-treatment physics tests. The results indicated that age did not play a significant role in their performance in these tests (p = .287 and p = .066, respectively, at α = 0.5). Similarly, tests were conducted to examine the relationship between self-esteem and the age and gender of the learners. The Independent Samples Mann-Whitney U test was utilized to determine the impact of gender on the students' self-esteem levels (p > .05), indicating that gender did not significantly influence their self-esteem. Moreover, the Independent Samples Kruskal-Wallis Test was employed to assess the influence of age on self-esteem levels. The findings revealed that age did not have any significant impact on the students' self-esteem levels (p = .757 at α = 0.05).

Table 2
Test for the effect of performance in physics and the level of self-esteem in the pre-test.

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between pre-test self-esteem results and physics pre-test equals 0.	Related-Samples Wilcoxon Signed Rank Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is 0.050.

Table 3

Testing the effect of Pre-treatment physics performance on the self-esteem levels.

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Pre-treatment Test Results is the same across categories of self-esteem levels for Test 1.	Independent Sample Kruskal-Wallis Test	.126	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is 0.050.

Table 4

Independent-Samples Kruskal-Wallis Test results of the effect of post-test physics results on learners' levels of self-esteem.

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Post-treatment Test Results is the same across categories of Self-esteem Levels for Test 2.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is 0.050.

In conclusion, it is important to note that factors such as the students' gender and age did not affect the relationship between academic performance and self-esteem levels. The primary influential factor in this relationship seems to be the use of the CLM (Constructivist Learning Approach), especially given that the effect of academic performance on self-esteem was not significant before the experimental process.

5. Discussion

The objective of this study was to examine the hypothesis that the utilization of the constructivist learning method and self-determination would not only reshape learners' personalities, but also enhance their critical thinking skills, which were believed to be key factors in achieving higher academic success.

However, this study revealed that there was no significant influence of learners' performance on their levels of self-esteem in the preliminary assessment test, categorized as high, average, or low. This suggests that prior to the implementation of the constructivist learning model as a new strategy during the experiment, the learning outcomes did not impact learners' overall self-esteem significantly. Nevertheless, the correlation between learners' self-esteem and academic performance or achievement had previously been established by Zuković and Stojadinović (2021), whose research indicated, among other findings, that students who struggled academically might also experience low self-esteem. If the results of the physics pre-test did not significantly affect learners' self-esteem levels, it implies that certain underlying variables, such as the teaching-learning approach not being entirely learner-centered, might have played a role in these observations.

Nonetheless, the post-test outcomes of this study demonstrated a connection between academic achievement in physics and learners' self-esteem levels. This outcome not only supports previous studies, but is also substantiated by Hassan et al. (2016), who highlighted the causative link between self-esteem and academic performance, and emphasized that high academic performance instills confidence, leading to elevated levels of self-esteem. However, this latter study did not guarantee that this relationship always holds true. Nonetheless, the positive association between performance on the physics test and self-esteem clearly indicates that students who perform well on the physics test after utilizing the constructivist learning approach are more likely to excel on the self-esteem test.

Note that these findings were contested by Wilson and Zoellner (2016), who discovered no impact of the constructivist learning approach on learners' self-esteem. However, their study only included high-achieving learners in regular conditions, resulting in homogeneous learner groups. Since the teaching and learning arrangement did not align with the actual constructivist classroom structure, this served as a moderating factor for the findings. Additionally, aspects such as the learner's attitude towards the subject and the subject's complexity may have the greatest influence on this effect (Gunarhadi & Shaari, 2014). A similar observation was made in this study and was supported by Woolfolk (2016), referencing William James' (1890) observation that learners' achievement in a specific subject will only lead to changes in their self-esteem if they attribute greater importance to that subject. This finding aligns with the symbolic interactionist assumption proposed by Moulton (n.d.) that the importance individuals place on elements in their environment guides their thoughts, as well as the contribution of the social environment to their self-esteem and achievement. However, the learners' attitudes and the subject's complexity, which were emphasized in this study, were not statistically verified as factors influencing the impact of constructivist learning methods on learners' self-esteem or performance. Nevertheless, the attitude and interest towards the subject can be fostered by stimulating learners' intrinsic motivation through the creation of a social environment enhanced by the constructivist learning-teaching approach.

Similarly, intermediate factors such as learners' intrinsic motivation (Zoabi, 2012), and critical thinking (Sudtho, Singhasiri, & Jimarkon, 2015; Woolfolk, 2016), which directly impact both academic performance and self-esteem, were not extensively explored in this study, although they were considered in the constructivist learning-teaching model used during the experimental process. It is recommended that future studies on similar issues delve deeper into these factors and variables as a central focus of their research.

This study has established three types of linkages observed in the classroom, in terms of the connection between academic achievement and learners' self-esteem. These linkages are identified by merging experimental results and secondary data findings, while also being influenced by constructivist learning-teaching strategies implemented in the educational process. Thus, the relationship between self-esteem and academic achievement can be described as follows: 1. There exists a mutual dependence between self-esteem and academic achievement, indicating that they are significantly intertwined. 2. The relationship between self-esteem and academic achievement can be considered symbiotic, as each aspect draws energy from the other in order to reach its full potential. Therefore, academic achievement boosts self-esteem, and vice versa. 3. The connection between academic achievement and self-esteem is double-noded, meaning that intrinsic motivation and metacognitive knowledge act as two key elements linking these factors. Both intrinsic motivation and metacognitive knowledge have been proven to strongly influence and interact with each other.

Moreover, the findings of this research suggest that the fundamental elements of academic achievement and self-esteem, specifically motivation and metacognitive knowledge, are enhanced through social interactions and the exchange of personal experiences within the constructivist learning approach. This is primarily due to learners' exploration and mastery of their metacognitive memory, resulting in decreased reliance on social influence and subsequently elevating their self-esteem and academic performance. Additionally, it is worth noting that metacognitive knowledge not only contributes to cognitive development and the cultivation of critical thinking skills, but also directly impacts academic performance. Fig. 1 visually represents the comprehensive intervention of constructivist learning-teaching methods.

Through the influence of the metacognitive knowledge developed during the constructivist learning-teaching process, learners' critical thinking is enhanced. This enhancement leads to an increase in cognitive growth and development, consequently improving their metacognitive knowledge. This knowledge is closely related to metamemory, which enables learners to assess their memory capacity and performance. As a result, learners become more intrinsically motivated, taking control and managing their own academic achievements.

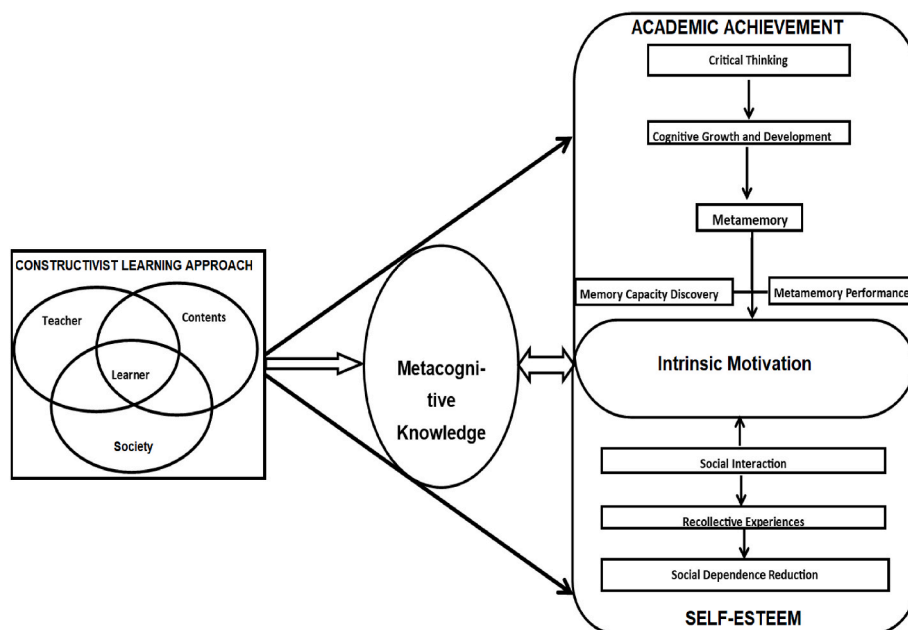Additionally, the use of the constructivist learning method,

Fig. 1. Visual model of effects of constructivist learning-teaching methods on the learners' self-esteem and academic performance.

combined with essential social interactions, helps learners develop crucial metacognitive strategies. These strategies, in conjunction with social interaction, enable learners to progress through the Zone of Proximal Development by effectively leveraging their own experiences and knowledge. Consequently, intrinsic motivation is further strengthened, reducing their reliance on social influence and contributing to an improved level of self-esteem.

This process fosters improved self-esteem, leading to a positive attitude towards the subject matter, increased interest in learning, and ultimately, enhanced academic performance.

6. Conclusion

According to the findings of this study, it is not accurate to solely evaluate a learner's educational success based on their academic performance. Therefore, it is important that the ultimate objectives of the learning-teaching process are not achieved until there is genuine cognitive growth and the development of emotional traits such as self-worth.

The study demonstrated how improving students' academic performance in a subject can enhance their interest in it, potentially leading to better future performance and increased self-esteem. Consequently, the efficacy of constructivist learning-teaching strategies directly correlates with students' academic achievements in science. This is due to the formation of diverse peer groups in the classroom using Constructivist Learning Methods (CLMs), which foster a positive influence among learners and boost their self-esteem.

Furthermore, it is worth noting that the constructivist learning-teaching approach is a double-edged sword, as it has the potential to enhance both academic achievements and self-esteem. The interdependence and mutual energy exchange between self-esteem and academic achievement are closely intertwined. Moreover, intrinsic motivation and metacognitive knowledge play crucial roles in connecting the two.

Notably, the predominance of social interactions and personal experience sharing in the constructivist learning approach increases motivation and metacognitive knowledge, which are vital factors for both academic achievement and self-esteem. Therefore, it is important to strive for an increase in learners' self-esteem to improve their academic performance. Similarly, when learners' self-esteem is elevated, their exceptional academic performance can be confidently anticipated.

Considering this study's conclusions, it is advisable to conduct further research with a specific focus on how learners' intrinsic motivation, critical thinking, and cognitive growth and development influence their academic achievement and self-esteem. Additionally, school administrations should encourage teachers to implement constructivist teaching strategies through Continued Professional Development (CPD) programs.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used Grammarly and Quillbot AI Technologies in order to finetune some parts of the work and proofreading. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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