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Can Project-Based Learning with Cognitive Behavioural Therapy Enhance Attitudes Towards Science?

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Abstract

Previous research yielded diverse results concerning the efficacy of Project-Based Learning (PBL) and raised concerns about potential adverse psychological and behavioural consequences. This study seeks to address these ambiguities and ascertain potential benefits of PBL with Cognitive Behavioural Therapy (CBT), an innovative educational strategy. This study investigates the effectiveness of an innovative educational approach that combines PBL with CBT; and evaluates its' impact on enhancing students' attitudes toward science in Malaysian primary schools. This study employed a quasi-experimental research design with primary school students in Malaysia as participants. Sixty students were selected and divided into two groups: one group received PBL with CBT, while the other was exposed to PBL. The use of one-way ANCOVA allowed for comparisons of the effects of these two treatments while controlling for covariates. The study finds there is a significant different in students' attitudes towards science following the PBL-CBT intervention. Mean scores for students in the PBL-CBT group were significantly higher compared to those in the PBL group. This suggests PBL-CBT approach has a positive impact on students' attitudes towards science. This contributes a novel approach to improving students' attitudes towards science through the combination of PBL and CBT. While prior research has explored these methods individually, this research bridges the gap by examining their synergistic effects.

Keywords: Project-Based Learning, Cognitive Behavioural Therapy, Attitude Towards Science, Instructional Methodology.

Introduction

Several studies have raised concerns about potential stressors, such as time commitments, workload, team dynamics, and management issues brought by Project-Based Learning (PBL) (Tuthill, 2023; Ruiz-Gallardo et al., 2016; Sirotiak & Walters, 2009). PBL teaching approach are overwhelming the students and lead to increased science anxiety, a psychological condition

arising from the struggles students faced in solving scientific problems in science classes (Sağır, 2012; Aydeniz & Ebru, 2012; Yaman, 2010; Van den Bergh et al., 2006). It is essential to recognize that science anxiety hinders learning effectiveness (Sağır, 2012; Karakaya et al., 2016). Negative attitudes toward science escalates as students disengaged in their learning process and triggers interpersonal conflicts or psychological challenges (Qarareh, 2016; Papanastasiou & Zembylas, 2002). Hence, integrating Cognitive Behavioural Therapy (CBT) with PBL is proposed in this study.

CBT, which leverages counselling theory and growth mindset principles, equips students with the skills to modify their thoughts and behaviours, thereby transforming emotional responses from negative interpretations and maladaptive thoughts to healthier ones (Bellini, 2017; Martin, 2016; Norcross & Goldfried, 2005). By fostering positive beliefs, CBT complements PBL, providing a comprehensive approach to promote positive attitudes. The adoption of CBT, typically used in medical research to address learning disorders among adult learners (Ramsay & Rostain, 2006), inspires this study.

So, this research proposed an approach combining PBL with CBT to offer a promising yet empirically untested teaching method. Limited research in the context of primary school education, has ventured into the application of CBT to alter students' attitudes toward science. Thus, this study seeks to address this gap. With a focus on fifth-grade primary school students, this research employs a quasi-experimental design involving two groups of respondents, each drawn from different schools but operating in similar learning environments.

The subsequent sections will delve into literature review, highlighting gaps in past research. Following this, is methodology section, followed by findings, discussion, and conclusion.

Literature Review

Background of Research

Based on the Trends in International Mathematics and Science Study (TIMSS) report, there is a serious decline in school students' attitude towards science (Ruthven, 2011; Phang et al., 2020). Positive attitude towards science is a stepping stone in preparing future work force in Science and Technology related career. However, low disposition towards science distorts the supply of skilled employees for science-related careers (Syed Hassan, 2018).

To overcome this problem, formulating effective science teaching method to foster positive attitude toward science needs urgent attention (Toma & Meneses Villagrá, 2019; Wendt & Rockinson-Szapkiw, 2018). Most research found that students' attitudes towards science decreases at the age of 10 and some claimed a sharp decline between age of eleven and fourteen (Osborne et al., 2010; Bennett & Hogarth, 2009). Study shows a decrease in interest for science commensurate with age (Pell & Jarvis, 2001; Ismail et al., 2014).

However, inconsistent empirical evidence on predictors of positive attitude towards science. Some studies show PBL exert science anxiety, hence affecting science attitude (Karakaya et al., 2016; Sagir, 2012). They claimed, PBL causes this contradictory outcome. Therefore, it is hypothesised, PBL alone will not nurture positive attitude towards science, but has affected students' psychology and demotivate students (Wedel et al., 2019).

Attribution theory and Achievement Motivation

Attribution theory and achievement motivation are integral components of cognitive psychology, playing a significant role in shaping students' attitudes and behaviour. Students attributed their behaviour to various factors, including achievement motivation (Kelley, 1973). These causal attributions play a crucial role in determining commitment to a given task, and this, in turn, strongly influences their attitudes (Platt, 1988; Weiner, 1972).

A positive attitude toward learning outcomes, especially in the field of science, resulting unwavering commitment and motivation to achieve goals. Hence, experiencing a sense of accomplishment. For students to actively pursue these objectives, they must firmly believe that their efforts and the control they exert over their actions significantly impact their achievement strivings (Griffin et al., 1983; Weiner, 1972).

Students with positive attitudes possess the necessary motivation and commitment to effectively engage in tasks, such as science learning through the Project-Based Learning (PBL) method (Wedel et al., 2019). These favourable attitudes can be traced back to their persistent behaviour. Their desire for achievement and the sense of pride derived from their accomplishments positively influence their future actions.

On the other hand, students harbouring negative attitudes toward science may require guidance and support to develop their achievement motivation. It is evident that the need for achievement and motivation are closely intertwined (Ariffin et al., 2017). Therefore, the integration of Cognitive Behavioural Therapy (CBT), a counselling theory, in combination with the PBL method, holds significant promise as an educational approach to assist students in the low-motivation group in demonstrating persistent behaviours and fostering positive attitudes toward science.

Limited study on CBT for students in school

Limited research has explored the application of CBT in educational settings, particularly in schools or universities. CBT is a widely recognized and effective psychotherapeutic approach for addressing various mental health issues (Dianti, 2023). This counselling method is designed to assist individuals in identifying and modifying negative thought patterns and behaviours associated with mental health challenges like depression and anxiety among students (Al-Mseidin & Al-Zu'bi, 2021; Aren & Duamit, 2020; Hakimi et al., 2019). While CBT is not typically intended as a direct means to enhance academic achievement, it can indirectly contribute to improved academic performance (Venkatesh Kumar & Sebastian, 2011; Murad, 2021; Ashraf et al., 2020; Ali Khaneh Keshi, 2013). CBT seeks to examine inappropriate feelings and behaviours, subsequently transforming maladaptive thoughts into realistic, accurate, and healthful interpretations of students' experiences.

The existing body of research predominantly focuses on college and university students (Kazemeini, 2011; Murad, 2021; Ramsay & Rostain, 2006), with limited attention given to its application within primary and secondary school contexts (Otu et al., 2022; Mohamed, 2017; Yousefian & Asgharipour, 2013; Venkatesh Kumar & Sebastian, 2011). According to Mohamed (2017), CBT interventions in a school setting aim to empower students in three keyways: (a) understanding the influence of their thought patterns on their behaviour, (b) acquiring control over these thought patterns, and (c) applying interventions to effect behavioural change. In the context of CBT studies, students are introduced to the concept of a growth mindset (Haimovitz & Dweck, 2017), fostering the belief that intelligence is not fixed (Lai et al., 2018). Additionally, students learn to set goals and combat negative thoughts, applying

these cognitive patterns and integrating CBT interventions into their lives and learning processes.

In an educational context, CBT represents a significant counselling theory that combines elements of Cognitive Theory (CT) and Behavioural Theory (BT). CBT's primary objective is to assess inappropriate feelings and behaviours and facilitate the transformation of maladaptive thoughts into realistic, accurate, and constructive interpretations of personal experiences (Fenn & Byrne, 2013). CBT in schools often draws inspiration from Ellis's theory, which follows the A-B-C sequence (Aithal, 2016; Pucci, 2010). This sequence delineates the relationship between Activating Events (A), which are everyday occurrences that prompt individuals to observe, interpret, or contemplate what is happening. The interpretation of these events results in specific Beliefs (B) about the event, the world, and one's role in the event. Subsequently, these beliefs give rise to Consequences (C), which are experienced based solely on the belief system in place.

CBT operationalization into science learning in schools' setting

CBT's integration into science learning in school settings relies on two fundamental principles: rational self-counselling skills and the interacting system principle. Through CBT, students gain the ability to counsel themselves in a rational manner, bolstering their confidence and paving the way for continued success (Pucci, 2010). This approach equips students with rational self-counselling skills since cognitive distortions can lead to intense emotions and inappropriate behaviours within specific contexts (Squires & Caddick, 2012). CBT, as a psychotherapeutic technique, actively reshapes everyday thoughts and behaviours, thereby fostering positive emotional outcomes (Martin, 2016; Norcross & Goldfried, 2005).

CBT also firmly adheres to the interacting systems principle (Westbrook et al., 2011). This principle encourages viewing problems as intricate interactions between thoughts, emotions, behaviours, physiology, and the surrounding environment in which an individual operates. Guided by these two principles, CBT empowers students to address emotional distress encountered during PBL promptly, without delving into underlying issues, by helping them identify and amend distorted thought patterns. This aids in alleviating tension and assures students of timely project completion.

CBT distinguishes itself from other counselling theories in two significant ways: (1) it does not necessitate deep insight into a person's psyche, and (2) it concentrates on observable behaviours. According to Corey (2016), CBT identifies the behaviour itself as the problem, not merely a symptom of an underlying issue. Inappropriate feelings and behaviours are attributed to individuals' interpretations of events, not the events themselves. The CBT model focuses on these interpretations and how they influence one's mood, emotions, and behaviours (Reinecke et al., 2003; Squires & Caddick, 2012). Furthermore, CBT is lauded for its effectiveness because it places a premium on solutions and offers short-term treatment (Bellini, 2017; Reinecke et al., 2003).

CBT interventions in a school context concentrate on helping students grasp three critical elements: (1) the impact of their thought patterns on their behaviour, (2) their ability to take control of these thought patterns, and (3) their capacity to apply interventions for behavioural change. CBT can be administered in group settings, as well (Dianti, 2023; Chandra et al., 2019; Yousefian & Asgharipour, 2013; Squires & Caddick, 2012). Consequently, CBT group therapy is a collaborative teaching and learning process in which group leaders and members work together to steer the group's direction and individual goal setting (Corey, 2016). In this way, CBT introduces students to the concept of a growth mindset, conveying the idea that

intelligence is not fixed (Schleider & Weisz, 2018). Students also learn to set goals and develop techniques to counteract negative thoughts. By employing CBT interventions, such as altering thought patterns, students can cultivate a more positive attitude when confronted with challenges in learning science.

CBT Intervention Tool of this study

In the context of PBL with CBT, the incorporation of growth mindset thought patterns into problem-solving activities played a pivotal role in reshaping students' attitudes during lessons. A fundamental prerequisite for educators in this approach was to gain insight into students' thoughts and emotions during learning activities. Students often communicate their feelings through their behaviour. For instance, if a student exhibited disruptive or non-compliant behaviour, it could be an indication of underlying emotions such as anger, fatigue, or irritability. As educators, it became essential to help students recognize and articulate these thoughts and feelings instead of acting upon them. This involved making students aware that feeling angry is distinct from the act of thinking.

Within this intervention, three key tools were employed: the ABC(D) Model, Growth Mindset, and SMART Goals. These tools, as acknowledged by Bellini (2017), were found to be well-suited for implementation in a school setting. Notably, CBT stands apart from other counselling theories in that it does not demand extensive insight into an individual's underlying issues or necessitate in-depth analysis. Instead, it places a primary focus on observable behaviour (Bellini, 2017).

ABC(D) Model

The ABC(D) Model, a key CBT intervention tool, is rooted in Ellis's A-B-C sequence theory (Aithal, 2016). This technique is implemented using the ABC worksheet and the A-B-C & D worksheet (Aithal, 2016; Bellini, 2017). The ABC 3-column form is a foundational CBT worksheet that aids individuals in capturing their thoughts and linking them to their emotions and the triggering events. The process typically unfolds in reverse, where one first identifies the troubling or problematic emotions and behaviours and then traces them back to the associated event and the exact thought accompanying it. This method facilitates a deeper understanding of the cognitive and emotional processes involved.

Growth Mindset

The Growth Mindset, as explored by Haimovitz & Dweck (2017), centres on the belief that students can significantly enhance their academic performance through hard work and dedication. This concept underscores the importance of educators providing students with strategies and support to empower them for success. As highlighted in this study, an individual's belief in their own potential holds profound implications for their actual achievements, aligning with the insights of Bellini (2017). Additionally, Bandura's research, as cited by Bellini (2017), emphasizes that individuals who possess a belief in their ability to succeed in a task are more likely to persist through challenges and setbacks. Even when failure occurs, the experience of progress through effort and determination can lead to improved self-esteem. According to Bellini (2017), the four fundamental tenets of the growth mindset encompass embracing challenges, learning from mistakes, accepting feedback and criticism, and demonstrating perseverance, focusing on the task at hand. These elements collectively contribute to fostering a growth mindset and its positive impact on academic achievement.

Smart Goal

Incorporating mutually agreed goal setting, CBT utilized the SMART Goal Handout as another valuable tool in this study (Fenn & Byrne, 2013). According to Fenn & Byrne (2013), effective goals should be 'SMART,' meaning they are Specific, Measurable, Achievable, Realistic, and Time-limited. The structure of CBT sessions aimed to enhance treatment efficiency, facilitate learning, and direct therapeutic efforts toward specific problems and their potential solutions. Sessions commenced with an agenda-setting process, during which the teacher assisted the students in selecting items conducive to productive therapeutic work in that session.

In the context of this study, the SMART Goal Handout served as a guideline for students to set their goals, motivating them to make progress toward their objectives. The teacher initiated the process by walking the students through a sample goal, using the SMART Goal Handout as a reference at the beginning of the lesson. Subsequently, students independently established their goals by following the steps outlined in the SMART Goal Handout (Bellini, 2017). To foster a collaborative environment, other group members were encouraged to provide suggestions regarding the goals and action steps. Table 1 in the study presented a set of recommended questions designed to facilitate the creation of SMART goals.

Table 1
SMART Goal with Questions

SMART Goal	Type of Questions
S (Make It Specific)	What exactly do you want to accomplish?
M (Measurable)	How will you know when you have accomplished your goal?
A (Make it Attainable)	What action steps will you need to take (daily, weekly, and other) to accomplish this goal
R (Realistic)	With hard work, dedication and motivation can I realistically achieve this goal? Is my goal realistically achievable? If the students answered no to one or both questions it means that the goal is not realistic. Students should revise until they can answer yes to both questions.
T (Make it Time-specific)	By when will you accomplish your goal?

The primary objective of this study was to assess the impact of integrating CBT into PBL on students' attitudes toward science. The study aimed to provide insights and findings that could aid students in utilizing CBT tools to develop a positive attitude toward science, ultimately fostering higher confidence and belief in their learning journey.

Consequently, the research question are as follows:
a. Is there a significant different in science attitude scores between the two groups: one using PBL without CBT and the other using PBL with CBT among Year Five students?
b. Does this innovative approach (PBL with CBT) result in significantly higher attitudes towards science compared to PBL without CBT among Year Five students?"

Method

Participants and Research Instrument

The participant of study is the year five primary school students. A total of sixty students participated in this study and they are divided into two groups. There are 30 students in each group. To avoid cross-contamination between the groups, each group of students was chosen from different schools but with a similar learning environment. The following are the controlling factors for the research instructors; they must be similar in experience, qualifications, and socioeconomic status. Table 2 exhibits the quasi-experimental design used in this study.

Table 2
Quasi-Experimental

Group	Pre-test	Treatment	Post-test
Experimental group 1	O_1	X1	O_2
Experimental group 2	O_1	X2	O_2

X1= PBL without CBT
X2 = PBL with CBT
O_1 = Pre-test
O_2 = Post-test

The instrument for this study is survey questionnaire adapted from Harlen et al. (1981), Pell & Jarvis (2001) and Westbrook et al. (2011) which applied a five point 'smiley face' Likert to identify the attitude changes. There are three main sections in the questionnaire; (1) 'science experiments' (has 10 items), (2) 'liking school' (has 12 items), and (3) 'what I really think of science' (has 21 items). There are a total of 43 items in the survey questionnaire.
The first section (Science Experiments) is used to measure students' feelings towards science experiments. The items and concepts were adapted from Assessment of Performance Unit material (Harlen et al. 1981). The language used in the selected items were rewritten to reflect the target population of Years five primary school students. On the other hand, the items in "What I really think of science" consisted of two measurements on the Science Enthusiasm and Social Context. Students are rating their feelings about science in the context of school lesson and science in the outside world.
The questionnaires were validated by a group of experts, a science university lecturer and school teachers. A group of five primary school students was also involved in validating the questionnaire. This is to confirm the questionnaire content and face validity. Besides that, the comprehensible language and grammar used in the items were checked by the science teacher to avoid misunderstanding the meaning of the items. A pilot test was conducted to

ensure and establish the reliability in face validity by identifying the instruments' weaknesses. The reliability index for the questionnaires was computed using Cronbach's alpha. Hence, when Cronbach's alpha coefficient at 0.84 was achieved, the items had proven a relatively high internal consistency.

Data Collection

The data collection and intervention were conducted in two weeks' time. During this period, both groups of students were guided in designing and building a model for the science topic on stability and strength and they involved in the hands-on PBL activities. Even though both groups used the same PBL teaching method in this intervention, the integration of the CBT into one of the groups PBL activities make the difference. In group one, students carried out the PBL activities without CBT while in group two, the students carried out the PBL activities with CBT.

In group one, students who underwent the PBL without CBT, they were given limited psychological encouragement and support during the PBL activities with instructors twice in a week. Students were only exposed to the way in solving the problems raised during the lessons without any motivation and encouragement. PBL activities in this group lacked a counselling element.

Meanwhile the other group who underwent PBL with CBT, carried out the session outlines which were adapted by Bellini (2017), whereby CBT was applied to encourage students to approach academic challenges in a new way and form new habits when it came to challenging coursework. The ABC(D) model, growth mindset and SMART goal were the three tools of CBT which were applied in this study. The ABC(D) model is a metacognitive tool used to help students to be aware of their 'thoughts' and use it to match the thoughts to feelings and events throughout the project (Aithal, 2016; Bellini, 2017). Then students identified their negative thinking and deliberately disputing the thoughts with more positive and healthier rational thinking. The growth mindset aims to change the student's belief in his or her own potential which then impacts his or her actual achievement (Bellini, 2017). Moreover, the SMART goal was used for the students to set a target and achieve them at the end of the project. The activities in PBL with CBT each week are valid by a teacher and a psychologist.

Data Collection through Bellini's session outline

To implement the PBL with CBT in group two, the study adapted session outlines suggested by Bellini (2017). The group began by reviewing information on growth and fixed mindsets, with the instructor explaining what could be expected in the group. In this context, the instructor provided an explanation of the ABC(D) model, walking the group through the process and actively seeking ideas and feedback as students worked through a handout using a generic example.

The ABC technique, rooted in the concept of irrational beliefs, aided students in recognizing that it was not the activating event itself that posed a problem in their lives (Aithal, 2016; Bellini, 2017). Instead, it was their irrational beliefs about the event that triggered negative emotions, subsequently leading to negative consequences, aligning with Ellis' Theory (Ellis, 1957). This activity allowed students to examine their beliefs about events in their lives and gain insight into how these beliefs influenced their feelings and emotions, in line with the fundamental principles of CBT. This psychotherapy is based on the modification of everyday thoughts and behaviours with the aim of positively influencing emotions (Norcross & Goldfried, 2005; Martin, 2016).

Subsequently, the instructor guided CBT activities with the group to foster a growth mindset. During this process, each student established an academic goal and regularly updated the group on their progress toward achieving it in each session. At the conclusion of the sessions, each member conducted a self-assessment of their own progress in developing a growth mindset. These session outlines were designed to instil in students the belief that their intelligence is not fixed. Additionally, students learned strategies to set and pursue their goals and acquired the skills to counteract negative thoughts when faced with obstacles.

The study's chosen mechanisms for classifying "well-defined CBT" interventions included the establishment of links between thoughts, feelings, and actions in relation to the target symptom, the correction of misperceptions, irrational beliefs, and reasoning biases related to the target symptom, as well as monitoring one's own thoughts, feelings, and behaviours related to the target symptom, and the promotion of alternative coping strategies. The session outlines recommended by Bellini (2017) fulfilled all these criteria. As a result, students aimed to develop a more positive attitude towards science, which, in turn, positively influenced their approach to learning in this study.

Data Analysis and Findings

One-way ANCOVA

The one-way ANCOVA was used to test the hypothesis by exploring the difference between intervention using PBL with CBT and PBL without CBT on the attitude towards Science among Year Five Students while statistically controlling the pretest as the covariate.

Table 3
Result of One-Way Ancova For the Significant Difference Between Pbl with Cbt Group And Pbl Without Cbt.

Dependent Variables: Post-test

Source	Type III Sum of Squares	*d.f.*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	1625.116[a]	2	812.558	13.206	.00	.32
Intercept	3036.66	1	3036.66	49.35	.00	.46
Pre-test	145.05	1	145.05	2.36	.13	.04
Group	1480.07	1	1480.07	24.05	.00	.30
Error	3507.28	57	61.53			
Total	463458.00	60				
Corrected Total	5132.40	59				

The ANCOVA test was conducted to identify the effect of PBL with CBT and PBL without CBT on two group students in students' attitude toward science after the effect of pre-test was controlled. There was a significant difference in mean of attitude towards Science F (1, 57) =24.054, p=0.000 between the groups, whilst adjusting for pre-test score. Null hypothesis is rejected because the p value is less than 0.05. The partial Eta Squared value indicated the effect size and should be compared with Cohen's guidelines (0.2 small effect, 0.5 – moderate effect, 0.8 – large effect) (Cohen, 1965). For the Group the effect size was small (0.297). This value was also used to describe how much of the variance in the dependent variable was explained by the independent variable (29%). Ideally this number would be fairly large. Refer Table 3.

Table 4
Estimated Marginal Means for Differences between PBL with CBT group and PBL without CBT at Post-test.

			95% Confidence Interval	
Group	*M*	Std. Error	Lower Bound	Upper Bound
PBL	82.43[a]	1.43	79.57	85.30
PBL with CBT	92.37[a]	1.43	89.50	95.23

The estimated marginal means in the section of the output gave the adjusted means by controlling the covariate 'test' for each group. This simply means that the effect of 'pre-test' has been statistically removed. From these adjusted means in Table 4, it is clearly implied that experiment group 2 which undergoes CBT with PBL has a higher attitude towards science after adjusting for pretesting. Estimated marginal mean of CBT in PBL is significantly higher than PBL. Based on the result, it can be concluded that PBL with CBT was more efficient than PBL without CBT in improving attitude towards science among Year five students.

Discussion

This section delves into the discussion of the findings regarding how CBT integrated with PBL improved science attitudes among primary school students. The discussion reflects on past PBL studies, examining their limitations from a psychological and behavioural perspective.

PBL with CBT for Primary School Students

Historically, research has concentrated on augmenting students' attitudes toward science, primarily highlighting the influence of PBL (Samsudin et al., 2020; Nordin et al., 2020; Samsudin et al., 2018; Nordin et al., 2016; Ismail et al., 2014). These studies have contributed invaluable insights, consistently concluding that PBL indeed shapes students' attitudes toward science (Rahim et al., 2022; Parno et al., 2019). However, the body of research in this domain is far from unanimous, with some studies offering an alternative perspective (Osborne et al., 2010; Sirotiak & Walters, 2009). Furthermore, there is evidence to suggest that PBL can induce stress and anxiety, leading to negative attitudes in students grappling with the challenges of PBL activities (Ruiz-Gallardo et al., 2016; Sirotiak & Walters, 2009).

Previous research has also underscored the limited consideration of students' psychological challenges within the PBL framework (Bellini, 2017). Consequently, primary school students who struggle with PBL, regardless of the quality of instruction or materials, may experience heightened anxiety and demotivation, often perceiving science learning through PBL as an insurmountable challenge. Cognitive psychology highlights the pivotal role of thoughts and behaviours in shaping how students approach learning tasks. Hence, this study explores the integration of CBT with PBL to foster positive attitudes toward science.

The results of this study substantiate the effectiveness of PBL when combined with CBT in improving students' attitudes toward science. The group that experienced PBL with CBT

exhibited substantial increases in attitude scores, with enhanced performance across all attitude scales between pretest and post-test assessments.

This study aligns with previous research by recognizing the potential advantages of PBL in shaping attitudes toward science (Calore, 2018; Ismail et al., 2014; Papanastasiou & Zembylas, 2002). However, it introduces a novel dimension by integrating CBT, acknowledging the psychological intricacies that students may encounter during the PBL process. This integration offers a more comprehensive and potentially more effective approach to enhance attitudes while mitigating potential negative consequences associated with PBL.

PBL with CBT Leads to Positive Attitudes

One noteworthy challenge of PBL is the potential burden it places on students and teachers (Ruiz-Gallardo et al., 2016). Despite its design to enhance student engagement and encourage self-directed learning, PBL can inadvertently lead to science-related anxiety. To address this issue, CBT emerges as an effective educational tool, empowering students to self-motivate throughout the PBL journey.

CBT interventions have been instrumental in reshaping students' attitudes toward science. Through CBT, students acquire the skills of rational self-counselling, leading to increased confidence, persistence, and commitment in their learning (Pucci, 2010). CBT, as elucidated by Norcross & Goldfried (2005) and Martin (2016), primarily focuses on modifying students' everyday thoughts and behaviours, thereby positively influencing their emotions and motivation.

Within the context of PBL-CBT, students are guided to reframe negative thought patterns. This study introduces the ABC(D) model, an effective guide for students to challenge irrational thoughts through evidence-based disputes, fostering healthier alternative thinking. Moreover, peer support, involving constructive feedback within team discussions using the ABC(D) model, is actively encouraged. This process equips students with the tools to scrutinize their beliefs about life events, highlighting how these beliefs impact their emotions.

These findings align with research by Mazana et al. (2019), emphasizing that attitudes encompass positive emotions, including happiness and increased motivation for learning. Anggoro et al. (2017) similarly underscore the significance of a joyful learning approach in enhancing primary school students' attitudes toward science. Thus, the results underscore the efficacy of CBT in reshaping students' attitudes toward science. The A-B-C sequence elucidated here demonstrates the interplay between experiences, beliefs, and reactions, providing a practical application of CBT to challenge and transform unhelpful attitudes (Corey, 2016).

PBL with CBT Overcomes Team Interaction Challenges

Team interactions within PBL have been identified as a significant source of stress (Osborne et al., 2010; Sirotiak & Walters, 2009). Such interactions can lead to negative feelings that, in turn, influence students' attitudes toward science learning. However, the ABC(D) model, a CBT tool, assists participants in overcoming irrational beliefs following disputes within group discussions (Aithal, 2016; Bellini, 2017). This model guides students to adopt more logical thinking after disputes, substantiating their feelings with concrete evidence. The act of recording their emotions enables students to shift from negative to positive emotions when confronting challenging situations.

The results indicate that PBL-CBT, utilizing the ABC(D) model, is highly efficient in positively influencing students' emotions during science classes, aligning with previous research by

Aithal (2016) and Bellini (2017). Positive statements from participants reflect the improved emotional state and a better experience of science classes. These results underscore that the integration of CBT within PBL is instrumental in enhancing students' attitudes toward science. The findings highlight the role of emotion in shaping students' attitudes toward science. Emotions experienced during classroom interactions significantly impact students' attitudes and can be addressed through proper classroom management, as noted by Urea (2015). CBT, particularly the ABC(D) model, aids in transforming students' irrational emotions.

Growth Mindset in PBL-CBT approach

Through the introduction of a growth mindset within the framework of CBT, students are instilled with the belief that they can be successful in any task. This study's results affirm that PBL when combined with CBT is more effective than PBL without CBT. The four key concepts of the growth mindset: embracing challenges, learning from mistakes, accepting feedback and criticism, and persevering (Bellini, 2017), played a pivotal role in reshaping students' attitudes when attending science classes. These results mirror the findings of Haimovitz & Dweck (2017), who demonstrated that when a child believe in their ability to succeed, they are more likely to persevere through challenges and setbacks.

Additionally, Lai et al. (2018) found that a growth mindset positively influenced graduate students' attitudes toward science subject such as biostatistics. Schleider & Weisz (2018) also emphasized the efficacy of growth mindset interventions in coping with stressors among adolescents. Notably, Larrier et al. (2016) also found that students who underwent the PBL combined with counselling approach were more inclined to offer constructive and supportive feedback to their peers among at-risk high school students. Hence, these showing that students developed a more positive attitude toward science as a result of the integrated PBL and CBT approach.

Theoretical Implications and Future Research

The central premise of this study asserts that CBT has substantial theoretical implications for science education through the PBL approach. Drawing upon attribution theory and achievement motivation, this research unequivocally demonstrates that the fusion of PBL with CBT exerts a significant influence on the likelihood of cultivating positive attitudes toward science. Within the context of a quasi-experimental design, this study meticulously scrutinized the comparative effectiveness of PBL with CBT in augmenting students' attitudes toward science, with a primary focus on Malaysian primary school students has enriched the scope of applicability of attribution and achievement motivation theory. However, it is imperative for forthcoming research endeavours to explore the transferability of these findings across diverse educational contexts, including secondary schools and tertiary education. Such investigations will furnish comprehensive insights into the generalizability of the PBL-CBT approach.

To unearth deeper layers of understanding regarding the intricate psychological mechanisms and experiential dimensions of students, it is recommended that future research integrates qualitative research methodologies, such as interviews. This methodological expansion promises to yield more nuanced insights into how the PBL-CBT approach shapes students' attitudes and refines their learning experiences, thereby contributing to a more holistic comprehension of its impact.

For a more robust and reliable assessment of the efficacy of the PBL-CBT approach in shaping attitudes toward science, researchers are encouraged to consider the enlargement of sample

sizes in quasi-experimental studies. This methodological enhancement is instrumental in reinforcing the generalizability and statistical reliability of research outcomes. A larger sample size enhances the representativeness of the findings, yielding a more comprehensive evaluation of the PBL-CBT approach's influence on attitudes toward science.

Practical Implications

The practical implications of this study transcend the realm of theoretical discourse and extend to educators, policymakers, and researchers, offering a promising trajectory for enhancing science education. Recognizing the imperative need for evolving teaching and learning courseware that seamlessly integrates CBT with PBL, the development of educational materials represents a transformative opportunity to enhance science education in primary schools. Given the substantial presence of primary school teachers within the Malaysian educational landscape, the provision of training and resources for enriching their skills in science instruction, coupled with counselling techniques, holds substantial potential for nurturing the nation's pool of scientific talents.

The recognition of the pivotal role that attitudes play in students' engagement with science should prompt primary school educators to contemplate the integration of the PBL-CBT approach as a fundamental component of their pedagogical strategies. By doing so, educators can foster a more positive and motivated approach to science learning among young students, thus enhancing their long-term relationship with the subject.

In light of the transformative potential of the PBL-CBT approach to stimulate scientific advancements and innovation in Malaysia, it is incumbent upon the government to prioritize this issue. Fostering positive attitudes toward science among primary school students is a strategic imperative for nurturing future generations of creative thinkers and innovators, making government involvement a necessity.

Conclusion

This study's originality lies in its pioneering intervention design, uniting two distinct pedagogical strategies, PBL and CBT, to synergistically impact students' attitudes toward science. By systematically examining the interplay between PBL and CBT, this research fills a significant gap in the educational literature. The implications of this study resonate not only in the theoretical realm but also in practical applications.

The PBL-CBT approach, fortified by the principles of Growth Mindset, equips students with the tools to not only cultivate positive attitudes but also to resiliently navigate the challenges inherent in scientific learning. Therefore, educators, policymakers, and researchers are urged to consider the profound potential of this pedagogical approach in reshaping students' attitudes and enriching science education.

In a broader policy context, this research underscores the importance of developing teaching and learning courseware that seamlessly integrates CBT with PBL. Such an approach has the potential to revitalize science education within primary schools, equipping teachers to effectively deliver science instruction and counselling techniques. Government involvement is pivotal in catalysing this transformation, as it can lay the groundwork for fostering innovative thinking and scientific advancements in Malaysia's educational and scientific landscape.

In conclusion, the confluence of PBL and CBT, fortified by the Growth Mindset, emerges as a potent strategy for reshaping students' attitudes toward science and igniting a passion for learning. We envision a brighter future where this innovative approach becomes a

cornerstone of science education, nurturing the minds of young learners and propelling Malaysia toward scientific excellence.

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