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A Quasi-Experimental Study of Project-Based Learning's Influence on Critical Thinking Skills Among Moroccan EFL Undergraduates

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Abstract

This research examined the effects of Project-Based Learning (PBL) on the development of critical thinking skills among undergraduate students in the English studies program at the Faculty of Arts and Humanities in Meknes during a 12-week intervention. A quasi-experimental design compared a PBL group to a traditional instruction control group. Critical thinking was assessed via pre- and post-tests and interviews. The independent samples t-tests showed no significant differences between groups in the pre-test; however, the PBL group demonstrated significant advantages in the post-test ($t(59.619) = -13.353$, $p < .001$). Paired samples t-tests confirmed within-group improvements for the PBL group. ANCOVA, controlling for pre-test scores, reinforced the significant positive effect of PBL on critical thinking. Semi-structured interviews were also conducted to back up the quantitative data. These results highlight PBL as an effective teaching method for developing critical thinking skills among undergraduate students in English studies. The study contributes to the growing body of evidence supporting PBL's efficacy in enhancing higher-order cognitive abilities.

Keywords: critical cognitive abilities, English studies, project-based learning, undergraduate students, higher education

1. Introduction

Critical thinking, a cognitive process encompassing analysis, evaluation, and synthesis, is indispensable for higher education and contemporary society (Facione, 2016). Developing these skills enables individuals to make well-informed decisions, tackle complex issues, and participate in meaningful critical discussions. As a result, educational research has increasingly focused on identifying teaching methods that successfully promote the development of critical thinking skills. Project-Based Learning (PBL), an instructional method centered on real-world problem-solving (Savery, 2006), has emerged as a promising strategy for developing these higher-order cognitive skills. Although empirical studies, such as Kolb (1984), demonstrate the effectiveness of PBL in improving critical thinking skills, there is a scarcity of research exploring its effects on EFL learners, especially in the Moroccan context. This study seeks to address this gap by examining the connection between PBL and the development of critical thinking skills among Moroccan EFL undergraduate students.

A substantial body of literature has established a positive correlation between PBL and critical thinking (Thomas & Brown, 1997). Participants engaged in PBL environments have demonstrated improved abilities to analyze information, evaluate evidence, and construct reasoned arguments (Jonassen, 1999). However, the majority of these studies have been conducted in predominantly English-speaking contexts, raising questions about the generalizability of findings to diverse linguistic and cultural settings. Moreover, the specific mechanisms through which PBL influences critical thinking development remain to be fully elucidated (Trilling & Fadel, 2007). To address these research gaps, this study delves into the Moroccan EFL context to examine the impact of PBL on students' critical thinking skills.

This research seeks to understand the extent to which PBL can enhance critical thinking among Moroccan EFL undergraduates. By investigating the relationship between these variables, this study aims to contribute to the theoretical and practical knowledge base in EFL pedagogy. The findings will guide the creation of effective teaching strategies that foster critical thinking and improve overall student learning outcomes.

The development of critical thinking skills is particularly relevant in the context of EFL education, as learners must not only acquire linguistic competence but also the ability to critically engage with English language texts and ideas (Hedge, 2000). Moreover, the integration of PBL into EFL curricula can provide opportunities for students to develop intercultural competence and global citizenship, essential skills in today's interconnected world (Byram, 1997). By examining the impact of PBL on critical thinking in this specific context, this study contributes to a broader understanding of the factors influencing EFL learners' cognitive development.

This study employs a quasi-experimental design to investigate the effects of PBL on critical thinking skills among Moroccan EFL undergraduate students. Participants will be randomly assigned to either a group experiencing PBL or a control group receiving conventional instruction. Pre- and post-tests assessing critical thinking abilities will be administered to both groups. Also, participants will be interviewed to provide more insights on their experience of PBL strategies. Quantitative analysis will be performed to evaluate the effectiveness of PBL in improving critical thinking skills. To do so, this study seeks to address the following research questions and hypothesis:

A. How does project-based learning impact the critical thinking skills of Moroccan EFL undergraduates?

B. To what extent does project-based learning enhance the critical thinking skills of Moroccan EFL undergraduate students?

DH: Project-based learning will lead to a significant improvement in the critical thinking skills of Moroccan EFL undergraduates compared to those receiving traditional instruction.

2. Literature Review

2.1 Theoretical Framework

2.1.1 Constructivism

Constructivism is a learning theory that posits knowledge is actively constructed by learners rather than passively received. It emphasizes the role of experience and reflection in building understanding. This viewpoint is consistent with Project-Based Learning (PBL), where students tackle genuine, real-world problems (El Moudden & Lamkhanter, 2024). By tackling complex problems, learners are encouraged to explore, experiment, and make connections between new information and their existing knowledge base. This active engagement fosters a deeper level of understanding and critical thinking.

Constructivism represents a departure from traditional, teacher-centered education that relied on rote memorization (Moussaoui & Erguig, 2023). It posits that learners actively create knowledge based on their experiences and interactions with the world. This perspective emphasizes the importance of social context in shaping understanding.

Unlike the traditional view of knowledge as objective and fixed, constructivism views it as a subjective and evolving construct. Individuals build their own understanding through engagement with their environment and interactions with others. This process involves reconciling new information with existing beliefs and creating new mental models (Pande & Bharathi, 2020). Consequently, knowledge is seen as a shared product of social interaction rather than an individual possession.

While constructivism encompasses various forms, this model focuses on knowledge that is not simply acquired but is co-constructed through dialogue, negotiation, and shared experiences (Güven & Valais, 2014). Truth, in this view, is not a fixed entity but a product of collective agreement and cultural practices.

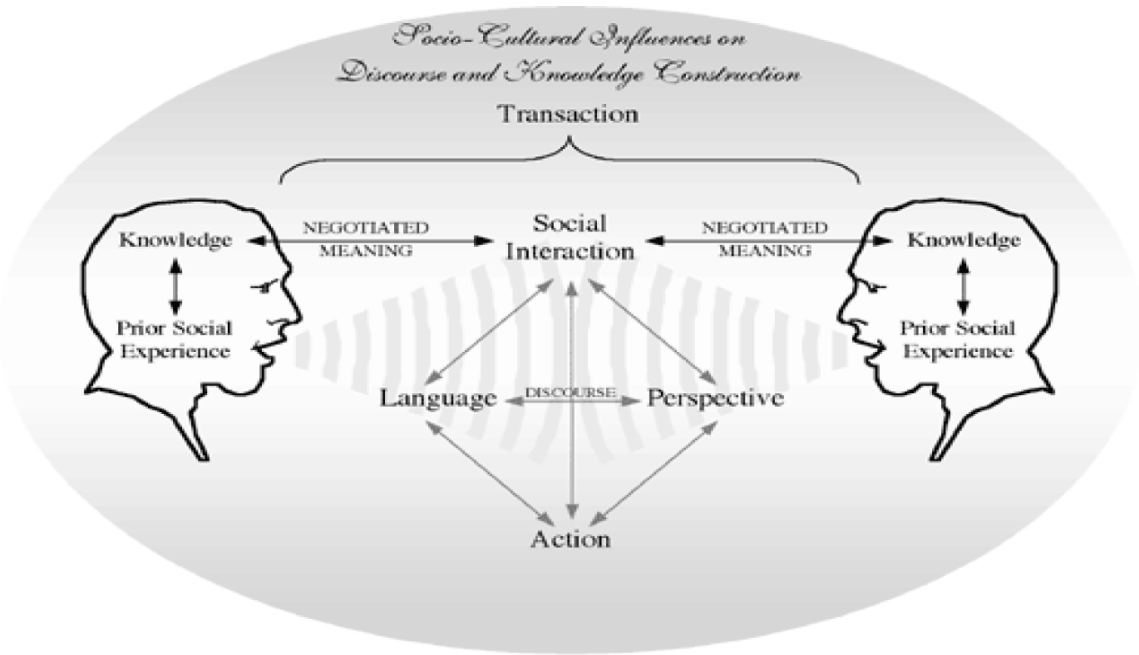

Figure 1: Diagrammatic Model of Social Constructivism (adopted from Doolittle, 2001, p,509)

According to Fosnot (1996),

> Learning from [a constructivist] perspective is viewed as a self-regulatory process of struggling with the conflict between existing personal models of the world and discrepant new insights, constructing new representations and models of reality as a human

> meaning-making venture with culturally developed tools and symbols, and further negotiating such meaning through cooperative social activity, discourse, and debate. (p. ix)

Constructivism provides a theoretical foundation for explaining how PBL can cultivate critical thinking skills. When students construct their own knowledge through PBL, they are inherently engaged in problem-solving, analysis, and evaluation (Kolmos & de Graaff, 2015). They must question assumptions, seek evidence, and justify their conclusions. This process of knowledge construction is intrinsically linked to critical thinking, as it requires learners to actively engage with information, analyze it critically, and apply it to new situations. (Piaget, 1936; Vygotsky, 1978)

Furthermore, constructivism highlights the importance of social interaction in learning. In PBL, students often collaborate with peers to solve problems, which encourages them to share ideas, challenge assumptions, and consider multiple perspectives. This collaborative environment stimulates critical thinking by exposing students to diverse viewpoints and fostering the ability to construct well-reasoned arguments. (Vygotsky, 1978)

2.1.2 Cognitive Load Theory

Cognitive Load Theory provides a robust framework for analyzing the cognitive demands inherent in Project-Based Learning (PBL). Sweller's seminal work in this area posits that the human cognitive system has limited working memory capacity, necessitating careful consideration of the instructional design to optimize learning (Sweller, 1988, 1994). In the context of PBL, this theory offers a lens through which to examine the mental workload imposed on students as they navigate complex problem spaces, collaborate with peers, and construct knowledge. By understanding the factors that influence cognitive load, educators can design PBL experiences that maximize learning while minimizing cognitive overload.

Cognitive Load Theory distinguishes between intrinsic, extraneous, and germane cognitive load (Sweller, 1994). While intrinsic load is determined by the inherent complexity of the task, extraneous load arises from ineffective instructional design. PBL, by its nature, often presents students with complex, ill-structured problems, thereby increasing intrinsic load (Zaafour & Salaberri-Ramiro, 2022). Thus, it is crucial to minimize extraneous load through careful planning and scaffolding to ensure that students can allocate cognitive resources to deep-level processing and problem-solving, which are essential components of critical thinking. Germane cognitive load, focused on meaningful learning and problem-solving, is the desired outcome of instruction.

Applying Cognitive Load Theory to PBL entails a systematic analysis of project design. This involves considering the complexity of the problem, the volume of information to be processed, the level of guidance provided, and the opportunities for students to engage in deep-level cognitive activities. By carefully examining these factors, educators can optimize PBL experiences to support the development of critical thinking skills. As Paas and van Merriënboer (1994) argue, effective instructional design should aim to reduce extraneous cognitive load while maximizing germane cognitive load, thereby facilitating the transfer of knowledge and skills to new problem-solving situations.

2.1.3 Sociocultural Theory:

Sociocultural theory, as conceptualized by Lev Vygotsky (1978), underscores the pivotal role of social interaction in cognitive development. This perspective aligns closely with the collaborative essence of Project-Based Learning (PBL). By prioritizing the influence of cultural, historical, and interpersonal factors on learning, Vygotsky provides a robust framework for understanding how PBL cultivates critical thinking (Vygotsky, 1978).

Central to Vygotsky's theory is the concept of the Zone of Proximal Development (ZPD), a dynamic space where learners can accomplish tasks with guidance from more knowledgeable peers or

adults. PBL environments, characterized by collaborative problem-solving, offer rich opportunities for students to operate within their ZPDs. Through shared inquiry, students can co-construct knowledge, challenge each other's thinking, and develop higher-order cognitive skills (Rogoff, 1990).

Furthermore, sociocultural theory emphasizes the role of language and discourse in shaping thought. PBL's emphasis on communication and argumentation provides a fertile ground for students to develop critical thinking skills. As students engage in dialogue, they refine their thinking, justify their reasoning, and consider multiple perspectives (Wertsch, 1991). This dynamic interchange of ideas fosters a community of learners where critical thinking is collectively constructed and internalized (Hamdanat, 2023).

Critical thinking, a cognitive process encompassing analysis, evaluation, and synthesis (Halpern, 2015), is paramount for navigating the complexities of higher education and contemporary society. As noted by Bloom's taxonomy (Bloom et al., 1956), higher-order thinking skills, such as critical thinking, are essential for student success. To cultivate these abilities, educators have explored innovative pedagogical approaches. Project-Based Learning (PBL), an instructional method centered on real-world problem-solving (Savery, 2006), has emerged as a promising strategy for fostering critical thinking.

PBL aligns with constructivist learning theories (Vygotsky, 1978) by emphasizing active learning and knowledge construction. By engaging students in authentic tasks and collaborative problem-solving, PBL offers a rich environment for developing critical thinking skills. Research has demonstrated the efficacy of PBL in enhancing students' ability to analyze information, evaluate evidence, and construct reasoned arguments (Thomas & Brown, 1997). However, while the positive impact of PBL on critical thinking is well-documented, further research is needed to explore its effectiveness in specific contexts, such as EFL education.

2.2 Critical Thinking and Higher Education

Critical thinking, a complex cognitive process involving analysis, evaluation, inference, and explanation (Facione, 2016), is fundamental to higher education. It encompasses the ability to reason effectively, make well-supported judgments, and solve problems (Paul & Elder, 2018). As defined by Halpern (2015), critical thinking involves skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information gathered from or generated by observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

The 21st century, characterized by rapid technological advancement, information overload, and complex global challenges, underscores the critical importance of critical thinking (Hamdanat, 2024). To navigate this dynamic landscape, individuals require the ability to analyze information critically, evaluate evidence, and make informed decisions. As noted by Trilling and Fadel (2007), critical thinking is essential for problem-solving, innovation, and effective citizenship.

Higher education institutions have a pivotal role in cultivating critical thinking skills (Sigman, 2019). They serve as platforms for students to develop the intellectual tools necessary for lifelong learning and engagement with the world. By incorporating critical thinking into curricula, fostering a culture of inquiry, and providing opportunities for students to apply their critical thinking skills to real-world problems, higher education can equip graduates with the competencies needed to thrive in the 21st century.

2.3 Project-Based Learning (PBL) and Education

Project-Based Learning (PBL) is an instructional approach that engages students in learning by actively exploring and responding to real-world challenges or problems. It is characterized by its student-centeredness, inquiry-based nature, and emphasis on authentic tasks. Key elements of PBL include authenticity, inquiry, student-centeredness, collaboration, and the creation of a product or presentation. Students work on projects over an extended period, conducting research, collaborating with peers, and producing tangible outcomes (Belmekki, Belmekki, & Koumachi, 2024).

The theoretical foundations of PBL are grounded in constructivist learning theory, which suggests that learners build knowledge through active engagement with their surroundings (Piaget, 1936; Vygotsky, 1978). PBL aligns with this perspective by providing opportunities for students to explore, experiment, and make sense of information. Furthermore, PBL is consistent with the principles of situated learning, which emphasizes learning in authentic contexts (Brown, Collins, & Duguid, 1989).

As a pedagogical approach, PBL has been shown to enhance student engagement, motivation, and critical thinking skills (Thomas & Brown, 1997). By immersing students in real-world challenges, PBL promotes deep learning and the development of problem-solving, communication, and collaboration abilities. Additionally, PBL can foster creativity, innovation, and self-directed learning, essential skills for success in the 21st century (El Bakkali, 2020).

2.4 PBL and Critical Thinking

A comprehensive review of empirical studies investigating the relationship between Project-Based Learning (PBL) and critical thinking reveals a generally positive correlation. Numerous studies have demonstrated that PBL significantly enhances students' critical thinking abilities. For instance, Alawi and Soh (2019) found a direct correlation between PBL implementation and the development of critical thinking skills. Similarly, Jusmaya and Efyanto (2018) reported significant improvements in students' critical thinking following PBL interventions.

These studies often employ quantitative research methods, such as experimental or quasi-experimental designs, to establish causal relationships between PBL and critical thinking. Statistical analyses, including t-tests, are used to compare the critical thinking performance of PBL and control groups. For example, Jusmaya and Efyanto (2018) reported a t-observed value of 3.83, which was significantly higher than the t-table value of 2.36 at the 0.05 level, indicating a statistically significant difference in critical thinking scores between the PBL and control groups.

While the majority of research supports the positive impact of PBL on critical thinking, it is essential to acknowledge the existence of contrasting findings. Some studies have reported no significant differences between PBL and traditional instructional methods in terms of critical thinking outcomes. Cash (2017), for instance, failed to find a significant effect of PBL on students' critical thinking skills. These inconsistencies may be attributed to various factors, including differences in study designs, sample populations, implementation fidelity, and assessment measures.

It is crucial to consider the complex interplay between PBL, critical thinking, and other variables. While PBL offers a promising approach to developing critical thinking skills, its effectiveness can be influenced by factors such as teacher training, curriculum design, and student characteristics (Waly & Ashadi, 2024). Additionally, the specific critical thinking skills targeted by PBL interventions may vary across studies, making direct comparisons challenging.

In conclusion, the preponderance of evidence suggests that teaching using projects is an efficient strategy for boosting students' higher-order thinking skills. However, further research is needed to explore the underlying mechanisms of this relationship, identify optimal implementation practices, and address the inconsistencies found in the literature. By refining our understanding of PBL's impact on critical thinking, educators can leverage this approach to its full potential.

2.5 PBL and EFL Context

This section reviews previous empirical studies on the relationship between project-based learning (PBL) and critical thinking skills. Several studies, including those by Alawi & Soh (2019), Anazifa & Djukri (2017), Ansori, Wasis & Nasrudin (2019), Cash (2017), Chiang & Lee (2016), Dimmitt (2017), Günay et al. (2019), Issa & Khataibeh (2021), Jusmaya & Efyanto (2018), Sari & Prasetyo (2021), Saripudin, Haryani & Wardani (2015), Sasson et al. (2018), and Wibowo et al. (2018), have explored this connection. While reviewing these studies, several limitations were identified. Notably, many

researchers relied solely on questionnaires to assess learners' perceptions of PBL's impact on critical thinking, without conducting experiments. For instance, Issa and Khataibeh (2021) used only a teacher's questionnaire, lacking experimental data to substantiate their claims about PBL's effectiveness.

Some studies, like those by Sari and Prasetyo (2021), employed multiple research instruments, such as observations, interviews, and questionnaires, but did not conduct experiments, making their conclusions about PBL's effectiveness less robust. Additionally, some researchers failed to control for extraneous variables that could affect the study outcomes, as acknowledged by Cash (2017). The duration of interventions was also a concern, with some studies, like those by Alawi and Soh (2019) and Chiang and Lee (2016), having insufficient treatment periods (four weeks and 16 hours, respectively) to draw definitive conclusions about PBL's impact on critical thinking.

Furthermore, several studies did not report the duration of the treatment or lacked pre- and post-tests to evaluate PBL's effectiveness. Studies that did use pre- and post-tests, such as those by Cash (2017) and Günay et al. (2019), often had small sample sizes, limiting the generalizability of their findings. Additionally, research by Saripudin, Haryani, and Wardani (2015) and Günay et al. (2019) employed a one-group pre-test post-test design without a control group, which compromises the validity of their findings due to potential confounding variables such as history and maturation (Tavakoli, 2012).

Another significant limitation is that in some studies, such as those by Saripudin et al. (2015) and Günay et al. (2019), the pre- and post-tests were identical, which can introduce a threat to internal validity due to participants' familiarity with the test content (Campbell & Stanley, 1963). This familiarity may lead to improvements in post-test scores that are not attributable to the intervention. Additionally, some studies did not verify the assumptions of homogeneity and normality when using t-tests, and many did not specify the sampling techniques used (Ku, 2009).

2.6 Critical Thinking Assessment

Assessing critical thinking is a complex endeavor that necessitates careful consideration of various tools and methods. As Facione (2016) argues, critical thinking is a multifaceted construct encompassing a range of cognitive skills. Consequently, a comprehensive assessment approach is required. Direct assessments, such as those outlined by Halpern (2015), involving tasks like essays and problem-solving, offer insights into students' ability to apply critical thinking to real-world challenges. Conversely, indirect assessments, relying on self-report measures, provide valuable qualitative data on students' perceptions (Bandura, 1997). However, as Ennis (1985) cautioned, self-report measures may not accurately reflect actual cognitive processes.

Despite the diversity of assessment tools, challenges persist. Developing instruments that comprehensively capture the complexity of critical thinking, as emphasized by Halpern (2015), is demanding. Moreover, the context-specific nature of critical thinking (Sternberg, 1984) hinders the creation of standardized assessments. The subjective evaluation inherent in assessing critical thinking products, as noted by Sadler (1989), can introduce rater bias. To address these challenges, researchers advocate for multiple assessment methods and triangulation of data (Shavelson, Baxter, & Pine, 2000) to obtain a comprehensive picture of students' critical thinking abilities.

3. Research Methods

3.1 Research Design

Given the constraints of random assignment in this study, a quasi-experimental design with a non-equivalent control group and pre-test/post-test measures was employed. As Creswell (2005) posits, this design is often necessary when researchers cannot form random groups due to practical limitations. This research design aims to examine the impact of PBL on undergraduate students' critical thinking skills by comparing two intact groups: an experimental group exposed to PBL strategies and a control

group receiving standard instruction. In addition to quantitative measures, semi-structured interviews were used to complement and support the findings.

3.2 Population and Sampling

Participants for this study were recruited from the Faculty of Arts and Humanities at Meknes University. They were primarily second-year undergraduate students aged between 21 and 27 years old. With a minimum of five years of English language study, including three years in high school and one in middle school, participants represented a relatively homogenous group in terms of language background. Due to the constraints of the study, a convenience sample of students was selected, resulting in two intact groups: an experimental group of 46 students and a control group of 40 students. Given the potential for pre-existing differences between these groups, independent sample t-tests will be conducted to assess their homogeneity on relevant variables prior to the intervention.

3.3 Data Collection Instruments

Critical thinking, a complex construct, has been defined in various ways across disciplines. While there is no universally accepted definition, a consensus exists regarding its core components. This study focuses on five key sub-skills: inference, assumption, deduction, interpreting information, and analyzing arguments. These sub-skills were selected based on their prominence in critical thinking literature and their representation in established critical thinking assessments such as the California Critical Thinking Skills Test and the Watson-Glaser Critical Thinking Appraisal. These instruments establish a basis for operationalizing critical thinking in this research. By concentrating on these core sub-skills, this study aims to provide a focused and measurable approach to assessing critical thinking development within the context of Project-Based Learning.

To address potential threats to internal validity, particularly test familiarity, two equivalent but different versions of the critical thinking test were employed for the pre-test and post-test. This approach aimed to reduce the possibility of participants performing better on the post-test simply due to familiarity with the test format or content.

In addition to quantitative measures, semi-structured interviews were employed to gain deeper insights into students' experiences and perceptions of their critical thinking development. Semi-structured interviews allowed for flexibility in exploring how students perceived the impact of Project-Based Learning on their critical thinking skills, providing context and nuance that quantitative tests alone may not capture. By incorporating participants' perspectives, the study aims to validate and enrich the quantitative findings, offering a more comprehensive understanding of the influence of Project-Based Learning on critical thinking. This mixed-method approach ensures a holistic evaluation of the effectiveness of the intervention in developing critical thinking skills.

3.4 Pilot Testing

Prior to full-scale implementation, the critical thinking test underwent a pilot phase involving 14 students from a similar population. The primary purpose of the pilot was to assess the test's reliability, validity, and clarity. The collected data were subjected to statistical analysis, including the calculation of Cronbach's alpha coefficient, which yielded a satisfactory value of .92, indicating high internal consistency of the test. Following the pilot study findings, the test instrument was revised to improve its clarity, reliability, and validity before being used with the main study sample.

3.5 Control of Extraneous Variables

Despite the use of a control group, external factors such as prior knowledge, teaching styles, and classroom dynamics could have affected the study's outcomes. To mitigate these influences, pre-tests were administered to assess baseline equivalency between groups. Additionally, both the control and experimental groups were taught by the same instructor to ensure consistency in teaching style. Classroom environment and resources were standardized across groups to minimize discrepancies in

learning conditions. While these efforts aimed to reduce the impact of extraneous variables, uncontrollable factors such as student motivation and external learning experiences may still have contributed to variations in performance.

3.6 Data Collection Procedures

To investigate the impact of Project-Based Learning (PBL) on critical thinking skills, a quasi-experimental design was employed. The experimental group engaged in PBL activities over a 12-week period, while the control group continued with traditional instruction. PBL projects were varied, encompassing tasks such as presentations, summaries, reviews, and reports to provide diverse opportunities for critical thinking development.

To assess changes in critical thinking abilities, a pre-test and post-test were administered to both groups. The critical thinking test measured five core critical thinking skills: inference, assumption, deduction, interpreting information, and analyzing arguments. This instrument was designed to evaluate participants' ability to apply these skills to various stimuli. The test was administered as an in-class assessment with a duration of 90 minutes.

In addition, 5 students from the experimental group were interviewed for about 10 minutes each to gain qualitative insights into their experiences with PBL. These semi-structured interviews were conducted to understand how students perceived the impact of PBL on their critical thinking skills. This qualitative data complements the quantitative results by providing deeper insights into students' personal experiences and the contextual factors that influenced their development of critical thinking. The interviews aimed to capture nuances and subjective interpretations that the standardized tests might not fully address, thereby enriching the overall evaluation of the PBL intervention.

3.7 Data Analysis Procedures

To evaluate the effect of PBL on critical thinking skills, quantitative data analysis was performed using SPSS version 21. Descriptive statistics, such as means and standard deviations, were computed for critical thinking scores to establish a baseline understanding of the data. Independent sample t-tests were employed to compare pre-test scores between the experimental and control groups, ensuring group equivalence at the outset. Paired sample t-tests were utilized to assess changes in critical thinking scores within each group from pre-test to post-test. To control for potential pre-existing differences in critical thinking abilities, Analysis of Covariance (ANCOVA) was conducted with pre-test scores as the covariate. By incorporating these statistical analyses, the study aimed to provide a comprehensive evaluation of the relationship between PBL and critical thinking development.

4. Results

4.1 Descriptive Statistics

This section aims to investigate the influence of Project-Based Learning (PBL) on the critical thinking abilities of Moroccan EFL students. Specifically, it aims to address the research question regarding the efficiency of PBL in improving critical thinking skills relative to traditional instruction. The corresponding directional hypothesis proposes a positive correlation between PBL and the enhancement of critical thinking skills within the target population.

A. How does project-based learning impact the critical thinking skills of Moroccan EFL undergraduates?

B. To what extent does project-based learning enhance the critical thinking skills of Moroccan EFL undergraduate students?

DH: Project-based learning will lead to a significant improvement in the critical thinking skills of Moroccan EFL undergraduates compared to those receiving traditional instruction.

This section aims to examine the impact of Project-Based Learning (PBL) on students' critical thinking skills. To achieve this, critical thinking abilities were assessed numerically through pre- and

post-tests. Critical thinking skills serve as the dependent variable, while PBL acts as the independent variable in this study. Independent samples t-tests, paired samples t-tests, and ANCOVA were employed to analyze the data. The following section presents, interprets, and discusses the results of these statistical analyses, including the strength of the relationship between PBL and critical thinking skills.

The study aims to test following Null hypothesis:

- **(H0)** There is no significant difference in critical thinking skills between students who participate in Project-Based Learning and those who receive traditional instruction.

Table 1: Descriptive statistics of the pre-test and post-test scores

Group Statistics

Group		N	Mean	Std. Deviation	Std. Error Mean
Pretest	Control	40	10,5375	2,22857	,35237
	Experimental	46	9,9783	2,29663	,33862
Posttest	Control	40	10,5500	2,22975	,35255
	Experimental	46	15,8696	1,25802	,18548

The Group Statistics table presents descriptive information regarding the sample characteristics. The control group (N=40) exhibited a mean pre-test critical thinking score of 10.5375, with a standard deviation of 2.22857, indicating moderate variability in scores. The experimental group (N=46) displayed a slightly lower mean pre-test score of 9.9783, with a comparable standard deviation of 2.29663. Post-test scores reveal a minimal increase in the control group's mean (10.5500) and a substantial increase in the experimental group's mean (15.8696), suggesting a potential positive impact of the PBL intervention on critical thinking development. Additionally, the experimental group's post-test standard deviation decreased, indicating a reduction in score variability and a more homogeneous improvement in critical thinking among this group.

Table 2: Independent samples t-test of the pre-test and post-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pretest	Equal variances assumed	,107	,744	1,142	84	,257	,55924	,48974	-,41466	1,53314
	Equal variances not assumed			1,144	82,969	,256	,55924	,48870	-,41277	1,53125
Posttest	Equal variances assumed	9,505	,003	-13,850	84	,000	-5,31957	,38408	-6,08335	-4,55578
	Equal variances not assumed			-13,353	59,619	,000	-5,31957	,39837	-6,11653	-4,52260

The Levene's Test for Equality of Variances indicates homogeneity of variance for the pre-test scores (p = .744) and heterogeneity of variance for the post-test scores (p = .003). Given the violation of

the homogeneity of variance assumption for the post-test, the results of the independent samples t-test assuming unequal variances should be considered. For the pre-test, the analysis showed no significant difference between the control and experimental groups (t(84) = 1.142, p = .257), suggesting that the groups were similar at the baseline. However, for the post-test, there was a significant difference between the groups, with the experimental group scoring significantly higher than the control group (t(59.619) = -13.353, p = .000). These findings suggest that the PBL intervention had a significant positive impact on critical thinking skills.

Table 3: Paired samples t-test of the pre-test and post-test

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 Pretest - Posttest	-3,15698	3,28456	,35418	-3,86119	-2,45277	-8,913	85	,000

The paired samples t-test results indicate a significant difference in critical thinking scores between the pre-test and post-test (t(85) = -3.157, p = .000). The mean difference between the pre-test and post-test scores is -3.15698, with a 95% confidence interval ranging from -3.86119 to -2.45277. These findings suggest that participants demonstrated significantly higher critical thinking scores on the post-test compared to the pre-test, providing evidence for the effectiveness of the PBL intervention in enhancing critical thinking skills.

Table 4: Levene's Test of Equality of Error Variances[a]

Dependent Variable: Posttest

F	df1	df2	Sig.
2,524	1	84	,116

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Pretest + Group

The Levene's Test of Equality of Error Variances for the post-test scores (F(1,84) = 2.524, p = .116) indicates that the assumption of equal variances across the experimental and control groups is not violated. This suggests that the variances in post-test critical thinking scores are similar between the two groups, which supports the validity of the subsequent analysis using the F-test in the ANCOVA.

Table 5: Tests of Between-Subjects Effects

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	761,418[a]	2	380,709	289,526	,000	,875
Intercept	193,709	1	193,709	147,314	,000	,640
Pretest	155,978	1	155,978	118,620	,000	,588
Group	673,975	1	673,975	512,553	,000	,861
Error	109,140	83	1,315			
Total	16302,000	86				
Corrected Total	870,558	85				

a. R Squared = ,875 (Adjusted R Squared = ,872)

The ANCOVA results indicate a significant effect of the independent variable (Group) on the dependent variable (Post-test critical thinking scores) after controlling for the covariate (Pretest) ($F(1,83) = 512.553$, $p < .001$, partial eta squared = .861). This finding suggests that the PBL intervention had a substantial impact on critical thinking skills beyond the influence of pre-existing differences in critical thinking ability. The large effect size (partial eta squared = .861) further emphasizes the practical significance of the intervention. Additionally, the significant effects of the intercept ($F(1,83) = 147.314$, $p < .001$) and pretest ($F(1,83) = 118.620$, $p < .001$) indicate that both the overall mean level of the post-test and the pre-test scores significantly contribute to explaining the variance in the post-test scores. This suggests that while the PBL intervention had a strong impact, the initial level of critical thinking as measured by the pre-test also played a role in predicting post-test performance.

4.2 Student Perceptions of Critical Thinking Enhancement through Project-Based Learning

Interviews with students were conducted to explore their perceptions of how Project-Based Learning (PBL) influenced their critical thinking skills. Participants described how PBL activities encouraged deeper thinking and problem-solving. One student noted, "The PBL activities pushed me to think more deeply about the problems we were solving. Working on real-world projects made me analyze information more critically and consider multiple perspectives before forming a conclusion." Another shared, "Before PBL, I mostly just memorized information. But with PBL, I had to apply what I learned to solve complex problems, which really improved my ability to make inferences and assumptions." A third participant remarked, "One of the biggest impacts was learning to work with others. The collaborative projects helped me see how different viewpoints can influence problem-solving and refine my arguments." Similarly, another student expressed, "The PBL format encouraged me to question my initial assumptions and explore evidence more rigorously. It wasn't just about finding answers but understanding the reasoning behind them." Lastly, one participant reflected, "I felt more engaged and motivated. The variety of tasks, from presentations to reports, required me to use and develop my critical thinking skills in ways I hadn't before." These interviews reveal that students found PBL to be a transformative experience for their critical thinking development, with the hands-on, real-world nature of the projects fostering deeper analysis, collaborative problem-solving, and a more reflective approach to their work. This qualitative feedback supports the quantitative findings, demonstrating that PBL effectively enhances critical thinking skills by providing diverse and engaging learning opportunities.

5. Discussion

This study investigated the impact of Project-Based Learning (PBL) on the development of critical thinking skills among Moroccan EFL students. The findings provide compelling evidence supporting the efficacy of teaching by projects in boosting critical thinking abilities. Consistent with previous research (Alawi & Soh, 2019; Jusmaya & Efyanto, 2018; Satya & Prasetyo, 2021; Hmelo-Silver, Duncan, & Chinn, 2007; Thomas & Brown, 1997; Bell, Smetana, & Fishman, 2009; Savery, 2006), the study revealed a significant positive association between PBL and the enhancement of critical thinking skills.

The experimental group, exposed to PBL, exhibited significantly higher gains in critical thinking scores compared to the control group, which received traditional instruction. These findings align with theoretical frameworks positing that PBL's emphasis on problem-solving, inquiry, and collaboration promotes higher-order thinking skills (Savery, 2006; Vygotsky, 1978). By engaging students in authentic, complex tasks, PBL provides opportunities for them to analyze information, evaluate evidence, and construct reasoned arguments (Facione, 2016; El Bakkali, 2020; Crespí, García-Ramos, & Queiruga-Dios, 2022).

While the current study contributes to the growing body of evidence supporting the effectiveness of PBL, it is essential to acknowledge certain limitations. The quasi-experimental design, while suitable for exploring causal relationships, does not establish definitive causation. Additionally, the study focused on a specific population, and the generalizability of findings to other contexts requires further investigation.

Future endeavours should probe in greater detail the mechanisms that underpin the relationship between PBL and critical thinking. Longitudinal studies tracking students' critical thinking growth over time are needed to assess the long-term effects of PBL. Furthermore, investigating the optimal components and implementation strategies of PBL is crucial for maximizing its impact on critical thinking development. Furthermore, investigating the impact of teacher training and support on the effective implementation of PBL is essential.

In a nutshell, the findings of this study strongly support the integration of PBL into educational curricula to enhance students' critical thinking abilities. By offering students opportunities for genuine problem-solving and inquiry, PBL enables them to develop into independent and critical thinkers. Further research is needed to refine our understanding of the factors influencing the effectiveness of PBL and to optimize its implementation for maximum impact.

6. Conclusion

This study investigated the impact of Project-Based Learning (PBL) on the development of critical thinking skills among Moroccan EFL students. The analysis of the data revealed that the experimental group, which participated in the PBL intervention, demonstrated a substantial improvement in critical thinking skills compared to the control group. The pre-test mean scores for the control and experimental groups were comparable; however, the post-test results indicated a significant enhancement in the experimental group, with their mean score rising from 9.9783 to 15.8696, whereas the control group's mean score showed only a marginal increase from 10.5375 to 10.5500.

The independent samples t-test results confirmed that there was no significant difference in pre-test scores between the two groups, establishing baseline comparability. However, the post-test analysis revealed a statistically significant difference ($t(59.619) = -13.353$, $p < .001$), with the experimental group scoring markedly higher. This significant difference supports the hypothesis that PBL has a positive effect on critical thinking skills. Additionally, the paired samples t-test indicated a significant improvement in critical thinking scores from pre-test to post-test ($t(85) = -3.157$, $p < .001$), reinforcing the effectiveness of the PBL intervention.

Further analysis using ANCOVA, which controlled for pre-test scores, demonstrated that the PBL intervention had a considerable impact on post-test scores ($F(1,83) = 512.553$, $p < .001$, partial eta squared = .861). This large effect size underscores the practical significance of PBL in enhancing critical thinking beyond initial skill levels. The ANCOVA results confirm that the observed improvements in critical thinking skills can be attributed to the PBL intervention, rather than pre-existing differences.

Qualitative feedback from student interviews corroborated the quantitative findings, highlighting that PBL activities fostered deeper analysis, collaborative problem-solving, and a more reflective approach to learning. Students reported that the real-world nature of PBL projects encouraged them to engage in critical thinking, consider multiple perspectives, and apply their knowledge to complex problems. These insights, combined with the quantitative data, affirm that PBL is an effective pedagogical approach for developing critical thinking skills. Future research should address the limitations of this study, such as its quasi-experimental design and sample constraints, and explore the long-term effects and broader applicability of PBL in various educational contexts.

7. Implications

The findings of this study hold significant implications for teachers, syllabus designers, and English studies departments in higher education. By highlighting the effectiveness of Project-Based Learning (PBL) in improving critical thinking skills, this research emphasizes the value of incorporating PBL into curriculum design.

7.1 For teachers, the study emphasizes the need for pedagogical shifts towards more student-centered and inquiry-based approaches. Teachers can incorporate PBL into their classrooms by designing

authentic projects that challenge students to think critically and solve problems. Moreover, teachers should receive adequate training and support to effectively implement PBL strategies.

7.2 **For syllabus designers**, the study highlights the importance of incorporating critical thinking outcomes into course objectives and learning outcomes. By aligning PBL activities with these outcomes, syllabi can be designed to foster the development of critical thinking skills. Additionally, the allocation of sufficient time and resources for PBL projects within the curriculum is essential.

7.3 **For English studies departments**, the findings underscore the need for a curriculum that emphasizes critical thinking as a core competency. Departments can foster a culture of inquiry by supporting faculty development in PBL pedagogy and by allocating resources for project-based learning initiatives. Furthermore, collaboration between faculty members from different disciplines can enrich the PBL experience by providing opportunities for interdisciplinary project-based learning.

By implementing these recommendations, higher education institutions can create a more engaging and intellectually stimulating learning environment that equips students with the critical thinking skills necessary for success in the 21st century.

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