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Issues and Ideas in Education

Impact of CLIL on Conceptual Understanding and Language Proficiency in Science Education

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ABSTRACT

Background: Content and Language Integrated Learning (CLIL) is a teaching methodology that integrates learning subject content with acquisition of proficiency in a foreign language (skills), developing both linguistic and conceptual competence. The approach aligns with the recommendations of the National Education Policy (NEP) 2020, which emphasizes the development of bilingual skills and cognitive abilities.

Purpose: The present study explores the efficacy of CLIL in science teaching, with particular emphasis on its influence on content knowledge, cognitive development, and bilingual language acquisition among pre-service teachers.

Method: A quasi-experimental pre- and post-test single-group design was adopted. The study was conducted on 20 pre-service teachers enrolled in the B.Ed. program at Chitkara University. A mixed-method approach was employed, incorporating both quantitative and qualitative data collection and analysis.

Results: Findings indicated that CLIL enhances vocabulary related to subject matter, deepens conceptual understanding through bilingual instruction, and increases student motivation and interest. It also positively impacts problem-solving skills and overall cognitive development, alongside improving language proficiency.

Conclusions: The study concludes that CLIL holds significant potential to enrich science education by fostering both cognitive and linguistic growth. However, challenges such as teacher preparedness and effective assessment strategies remain. The research highlights the need for further investigation into long-term outcomes and teacher training to maximize the educational benefits of CLIL.

1. Introduction

1.1. CLIL: Meaning and Definition

According to Coyle *et al.* (2010), Content and Language Integrated Learning (CLIL) is defined as an efficient pedagogy that integrates the content of the subject with the learning of language and has greatly enriched the art of teaching science through the accumulation of conceptual and linguistic skills in the 4Cs framework: content, communication, cognition, and culture.

Content and Language Integrated Learning (CLIL) is a teaching methodology in which foreign language instruction is used to teach subjects, with the goals of both improved language and subject matter proficiency (Marsh, 1994). Academic content, for example, science or history, is learned by students in a CLIL environment as they enhance their proficiency in the target language, for example, English. This method is rooted in cognitive and language acquisition theories, supporting critical thinking and active learning. CLIL has been extensively used in multilingual and bilingual education contexts, providing advantages like enhanced language proficiency, higher cognitive flexibility, and more effective subject matter learning (Aravind, 2018). Though it has its drawbacks, such as requiring competent teachers well-versed in the topic as well as the target language and the challenge of measuring the achievements of the students in both aspects, there is research done on CLIL. It discusses the effectiveness of CLIL, establishing best practice, results, and topics

that require further study to improve the educational experience (Kim & Graham, 2022).

1.2. CLIL: Teaching Advantages

CLIL (Content and Language Integrated Learning) in science education offers numerous advantages. It improves students' scientific vocabulary and language skills by teaching subject-specific terms in the target language, which enhances their ability to understand and communicate complex scientific ideas (Marsh & Lange, 2000). Moreover, it encourages the development of cognitive skills, such as critical thinking and problem-solving, as students work with scientific content while managing the language demands of a second language (Coyle *et al.*, 2007; Swain & Lapkin, 2001). CLIL also boosts motivation and engagement by making the integration of language and real-world scientific topics more interesting and relevant (Lasagabaster & Sierra, 2009). In addition, it strengthens content knowledge by helping students apply scientific concepts in meaningful, real-world contexts (Pavesi & Coonan, 2015), while preparing them for global scientific conversations by improving their ability to read, understand, and communicate in a widely used language like English (Baker, 2011; Lorenzo *et al.*, 2009). Overall, CLIL promotes both academic and linguistic development, making it an effective method for teaching science.

1.3. Relevance of the Study

There is a necessity for this study on Content and Language Integrated Learning (CLIL) because of the increasing need for bilingual or multilingual skills in the globalized world, where students must acquire academic content in a second language. CLIL is a silver bullet in that it can potentially enhance both subject and language knowledge at the same time, yet not much research has been done to investigate its effectiveness and methods of implementation. The significance of this research lies in its ability to enhance teaching practices through an illustration of how CLIL can evolve not just language abilities but also thinking skills, critical thinking, and subject content mastery.

Most of the studies have been conducted at the elementary school level, mainly using survey-based methods. While there are a few experimental studies in subjects beyond science, only one study has been found that critically examines the CLIL (Content and Language Integrated Learning) pedagogy in the Indian context. The present research aims to investigate how the use of CLIL pedagogy enhances language proficiency and concept attainment in science. The present research paper can contribute towards helping teachers in embracing best practices and improving teaching approaches with special focus on the teaching of science.

1.4. Objectives

- To study the improvement in scores in science with CLIL intervention.
- To study the attitude of aspiring teachers towards CLIL pedagogy.

1.5. Hypothesis

Ho1: There is no statistically significant difference between pre-test and post-test scores in science with CLIL intervention**.**

2. Literature Review

Huttner and Smit (2014) proposed that CLIL enhances intensified critical thinking ability and problem-solving skills, leading to improved student performance in scientific subjects. Dalton-Puffer (2011) discovered CLIL students only outperformed non-CLIL students in the application of scientific vocabulary because CLIL ensures greater utilization of authentic texts and communicative interactions. In addition, Lasagabaster and Sierra (2009) contend that CLIL instigates greater motivation by utilizing real purposes and cross-curriculum instruction. However, Prez-Canado (2012) and Morton (2013) discovered relevant problems like the paucity of proficient teachers and the difficulty of balancing content and language instruction assessment strategies. Llinares and Morton (2017) noted that there is a need to measure both scientific content and language skills through formative assessments and holistic assessment models. Wolff and Frigols (2012) denoted the promise of CLIL for STEM instruction, and Kelly and Clegg (2015) underscored technology's role in developing interaction with digital content and multimedia resources.

To conclude, the studies revealed that while CLIL makes a great contribution to the learning of science, it relies on competent teachers who have undergone proper training, right testing, techniques, and adequate

provision of resources, requiring more studies of long-term effects and in-service courses of teacher education.

3. Methodology

3.1. Research Design

The study followed a quasi-experimental single group pre-post-test only design.

Table 1: Tabular Representation of a Quasi-Experimental Single Group Pre-Post-Test Only Design

Time Duration	Phase	Group	Treatment	Measurement
3 Periods	Pre-test	Single	CLIL Intervention	Post-test

3.2. Sample

The sample of the study included 20 pre-service teachers of Semester 2 and 4 of the B.Ed. course from the Department of Education, Chitkara University.

3.3. Data Collection Methods

The study employed a mixed-methods approach, incorporating both quantitative and qualitative analysis. Pre- and post-tests were administered for quantitative data collection, while qualitative insights were gathered through participant feedback.

3.4. Data Analysis

A t-test was employed for the quantitative data analysis, and thematic analysis was carried out for the qualitative data.

3.5. The CLIL Process

For the CLIL-based teaching, the lesson 'Mindful Eating: A Path to a Healthy Body' from the NCERT Science textbook Curiosity, prescribed for Grade Six, was taught to the selected group.

The investigator introduced key nutritional terms—carbohydrates, proteins, fats, vitamins, and minerals—in both the target languages: English and Hindi.

In the first step, the concept was taught in Target Language 1 (English):

- *Carbohydrates* and *fats* were explained as energy-giving foods,
- *Proteins* as body-building foods, and
- *Vitamins* and *minerals* as protective foods.

In the second step, the concept was taught in Target Language 2 (Hindi):

- *Carbohydrates* (कार्बोहाइड्रेट्स) and *fats* (वसा) were explained as energy-giving foods (ऊर्जावान),
- *Proteins* (प्रोटीन) as body-building foods (शरीरनिर्माणभोजन), and
- *Vitamins* (विटामिन) and *minerals* (खनिज) as protective foods (सुरक्षात्मकभोजन).

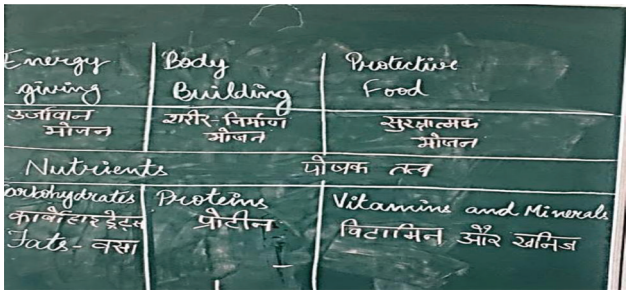

Figure 1: Bilingual Explanation of the Content using Blackboard as Teaching Aid

In the third step, to reinforce these concepts, the investigator used pictures and bilingual labels to help students associate the terms with their meanings. Students actively participated by translating these terms into English and Hindi and explaining their functions in a balanced diet**.**

3.5.1. Illustration

The investigator displayed a food pyramid chart having images of rice, dal, vegetables, etc., and asked students to categorize each item as per the nutrients while recalling the scientific terms in both the English and Hindi languages.

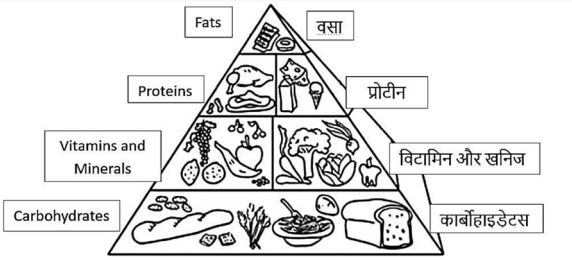

Figure 2: Bilingual Explanation of the Content using Digital Chart Representation

4. Data Analysis

4.1. Quantitative Analysis

Ho1: There is no statistically significant difference between pre-test and post-test scores in science with CLIL intervention.

The improvement in the prospective teacher's scores in science and mathematics was analyzed for statistical significance. The t-test was conducted to compare the pre- and post-test scores obtained in science and mathematics by the group.

Table 2: Difference between Pre and Post-test Scores of the Group in Science

Group (Single)	N	Mean	Std. Deviation	t-value	p-value
Science Pre	20	6.000	1.777	9.705	.0001**
Science Post	20	9.950	2.139	-	-

The results from Table 2 indicate that the mean score in the pre-test (M = 6.000, SD = 1.777) is significantly lower than in the post-test (M = 9.950, SD = 2.139), with a mean difference of t(38) = 9.705, p = .0001.

Since the p-value (.0001) is less than the conventional level of significance (0.01), it suggests that there exists a statistically significant difference between the pre- and post-test scores before and after the CLIL intervention.

4.2. Qualitative Analysis

The feedback from the surveys indicated positive remarks on the use of CLIL in science learning. Both teachers and students noted ease of language switching, content clarity, and the advantages of pedagogy in bilingualism. Combining the mother tongue and target language facilitated students' understanding of complicated scientific principles better, reducing cognitive overload and raising interest.

A systematized bilingual teaching approach complemented with visual aids, day-to-day language usage, and interactive classroom debates helped in enhancing better understanding and retention of scientific information. Student teachers noted that students became more confident about expressing scientific concepts in both languages, and thus, their language ability in general increased. Academically, aside from improved academic performance, the bilingual learning environment helped enhance communication skills.

While it was effective, there were some responses that highlighted the necessity for further teacher training and the creation of tailored teaching materials to optimize CLIL's potential in various learning environments.

5. Results

- The mean post-test score (M = 9.950, SD = 2.139) was notably higher than the mean pre-test score (M = 6.000, SD = 1.777), with a t-value of 9.705 and a p-value of .0001. This suggests the positive impact on students' understanding of science concepts with CLIL intervention.
- CLIL pedagogy improved concept clarity, enhanced language acquisition, bridged concept attainment gaps, and fostered participant engagement and motivation through its collaborative benefits.

6. Discussion and Conclusion

- The findings revealed a statistically significant improvement in the pre-test and post-test before and after the CLIL intervention. The increase in scores indicated that even conventional instructional approaches, when implemented effectively, led to meaningful gains in student learning outcomes. However, it is important to note that the effectiveness of traditional methods may be limited in promoting deeper conceptual understanding or language integration compared to more innovative pedagogies such as CLIL.
- CLIL proved to be a powerful tool in science instruction, as it simultaneously strengthened students' understanding of scientific concepts and improved their language skills. This dual focus fostered a deeper, more meaningful learning experience and encouraged collaboration between language and subject teachers, promoting an integrated teaching-learning process.
- CLIL made complex scientific ideas more accessible by immersing students in content while building language proficiency. It also provided a meaningful context for assessing students' proficiency in both English and Hindi within the science classroom.
- CLIL nurtured higher-order thinking skills such as reasoning, analysis, and problem-solving. It prepared students to manage both linguistic and conceptual challenges, reinforcing the importance of integrating CLIL-based strategies into the science curriculum at a national level.
- Beyond academics, CLIL promoted cultural sensitivity and multilingual competence. It aligned with national initiatives like 'Ek Bharat, Shreshtha Bharat', enabling students to engage with diverse languages and scientific perspectives to solve problems at both local and global levels.

7. Future Perspective

- This research was carried out using a small sample size; hence, the same research would be undertaken with a larger sample to improve the generalizability of the results.
- Subsequent studies would also be conducted across various disciplines to examine the general applicability of CLIL. Moreover, studies would also be done to compare content knowledge and language proficiency independently to have a better understanding of their respective effects.
- The study used a pre-post-test single-group design. Control and experimental groups should be included in subsequent studies to provide more detailed comparative information.
- Studies on the level of engagement and motivation of students in CLIL-based learning environments would give insight into its effectiveness. Additionally, the potential of CLIL to increase cultural sensitivity by investigating how science is delivered across cultures is worth exploring further.
- Moreover, studies can investigate the ways in which CLIL promotes teamwork and collaboration between the students and teachers, leading to more cooperative and interactive learning.

Abbreviation

CLIL: Content and Language Integrated Learning

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Authorship Contribution

Nishtha: Responsible for conceptualization, literature review, data collection, and initial drafting of the manuscript; Jyotika Guleria: Conducted statistical analysis, developed the research methodology, and contributed to the interpretation of results and revision of the manuscript; and Kanchan Gupta: Provided logistical support and facilitated the research environment necessary for conducting the study.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Declarations

There are no specific declarations to be made regarding this article.

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