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Investigating the impacts of culturally relevant engineering design (CRED) on students' perception and engagement in k-12 stem classroom

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Abstract

This study highlights effective strategies for enhancing student interest and participation in STEM education through culturally relevant approaches. Both quantitative and qualitative research approaches were engaged for this study. A survey was created and sent online to a group of grade 8 to 12 STEM students who completed the study. The interview questions were made and sent to 6 teachers. The qualitative data was taken and analyzed using descriptive findings and quantitative data was taken and analyzed via the Statistical Package for the Social Sciences (SPSS) software to find relationships between culturally relevant engineering design (CRED) and students' perceptions and engagement in Science, Technology, Engineering, and Mathematics (STEM) classrooms. Our findings reveal a significant positive correlation between students' perceptions of culturally relevant engineering design and their engagement in STEM learning activities. Specifically, students who perceive culturally relevant engineering design positively demonstrate higher levels of engagement in STEM learning.

Keywords: CRED; STEM learning; positive correlation; student engagement

1. Introduction

This study aims to investigate the impact of culturally relevant engineering design tasks on students' perception and engagement in science, technology, engineering, and math (STEM) classrooms in Nigeria. In recent years, in my classroom, I have observed that students are becoming less interested in STEM teaching and learning activities and engineering design tasks. This has given me concern because according to Tai et al. (2006), encouraging students' interest in STEM learning activities at an early stage of education is essential to students' interest in science and engineering at the university and in the STEM career later in life.

1.1. Context

This action research is developed to investigate and find innovative interventions for students' disengagement in STEM learning activities in Nigeria. The school is an elementary STEM-focused school with a mission to equip learners with competencies for life. The school aims to equip the learners with skill sets relevant to the future of work such as critical thinking, problem-solving, machine learning, collaborative skills, and so forth. The school began operation in January 2021, and today has more than 100 students in classes from K-5. The school is established for children from the ages 0 – 12. The school has a total staff strength of 15 (10 teaching staff and 5 non-teaching staff), and the head of the administration office is the founder of the school and a student at the University of the People. The founder is interested in knowing how to help learners at the school succeed in their academic pursuits, hence the reason for enrollment in the Master of Education at the University of the People.

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1.2. Statement of the Problem

The problem is the decline in students' engagement and interest in STEM education at a school in Nigeria. This problem is critical because Tai et al. (2006) stated that early interest in STEM subjects is a major factor that often enables students to develop an interest in pursuing STEM-related courses and careers in the future.

Realizing how urgent it is to deal with the issue of students' disengagement, this research aims to test and investigate the impacts a culturally relevant engineering design approach to teaching STEM subjects will have on both the teachers and the students. We aim to explore how this innovative approach may positively influence student engagement and revitalize students' interest in STEM subjects among students in a school in Nigeria.

1.3. Rationale

The rationale for this study lies in the urgency to address declining student engagement and the underrepresented of some demographics in STEM, the recognized importance of early STEM interest, the potential effectiveness of culturally relevant approaches, the pursuit of inclusivity and equity, the desire to innovate in pedagogy, and the practical implications for educators and the global education landscape.

There have been limited studies into the investigation of the effectiveness of culturally relevant engineering design on increasing students' interest and engagement in STEM education and how culturally relevant engineering design can be adapted into a STEM classroom. This research aims to investigate what impacts the promotion of inclusivity, equity, and diversity in engineering design tasks in the classroom will have on both the teachers and the students.

1.4. Prior Interventions

Casler-Failing et al. (2021) began their journal introduction with an inquisitive question: "How do we create opportunities that support middle-grade students in becoming interested in a STEM field?" This question is still as relevant today as when they first asked that question. The most authentic answer they could come up with is culturally responsive practices; so, in this research study, I have decided to investigate how culturally responsive practices can lead to student's improved engagement in STEM classrooms. Hussar and Bailey (2017) argued that a traditional standards-based STEM curriculum has not prompted significant improvement in students' interest in STEM education. Some researchers have further engaged in studies to discover what to do to improve students' interest in STEM classrooms, and one of the greatest discoveries in improving students' interest points toward culturally responsive practices.

1.5. Research Questions

- Can the implementation of culturally relevant engineering design principles enhance students' engagement and interest in STEM classrooms?
- How do the teaching styles, methods, and curricula employed by STEM educators impact student engagement?

1.6. Significance of the Study

The significance of this study lies in the urgency to address declining student engagement in STEM, the recognized importance of early STEM interest, the potential effectiveness of culturally relevant approaches, the pursuit and promotion of inclusive and diverse engineering design tasks in the classroom, the desire to innovate in pedagogy practices, and the practical implications for educators and the global education landscape. The findings from this study will also contribute to the body of knowledge in the STEM fields and will help researchers, educators, and policymakers understand more about how students' engagement and disengagement are relevant to engineering design. The results from this study will also address gaps in existing knowledge and will help educational researchers and educators understand more about the relationship between culturally relevant engineering design, STEM subjects, and student engagement.

2. Literature review

2.1. Introduction

This study investigates the impacts of Culturally Relevant Engineering Design (CRED) on students' engagement and perceptions in STEM classrooms. Despite the growing importance of STEM education in preparing students for future careers and addressing workforce needs, disengagement in STEM remains a significant challenge, particularly for

students from underrepresented backgrounds. This literature review synthesizes existing research to explore how culturally responsive practices, particularly CRED, can enhance engagement and foster inclusivity in STEM education.

2.2. Theoretical Framework

The review is organized around theoretical frameworks and perspectives relevant to STEM education and culturally responsive pedagogy. Subsections address key themes, including the causes of disengagement, the importance of STEM education, and the principles and effectiveness of CRED, contextualized within existing research.

2.3. Disengagement in STEM

Disengagement in STEM classrooms is a persistent global concern. According to the OECD (2008), students across developed nations are disengaging from STEM due to various psychological and sociocultural factors. Flanagan et al. (2022) highlight that feelings of exclusion, lack of belonging, and perceptions of discrimination contribute significantly to this issue. Additionally, the disconnect between students' cultural backgrounds and STEM curricula further exacerbates disengagement.

While numerous interventions have aimed to address this problem, educators and researchers still lack a comprehensive understanding of the contributing factors and effective solutions (Hall & Miro, 2016; Dowling & Brown, 2012). This study builds on these gaps, investigating whether CRED can serve as a viable strategy to improve engagement.

2.4. Importance of STEM Education

STEM education is vital for preparing students to meet global workforce demands and fostering innovation in science and technology. Mulvey et al. (2023) emphasize that STEM education not only equips students with critical skills but also contributes to economic prosperity. Roehrig et al. (2021) advocate for increased federal support to strengthen STEM initiatives, citing the need for a well-prepared STEM workforce to sustain national competitiveness.

2.5. Consequences of Disengagement

The societal implications of STEM disengagement are far-reaching. De Loof et al. (2021) argue that widespread disengagement could result in a generation of students ill-equipped to navigate a technology-driven world. Addressing this issue requires innovative educational approaches that inspire and retain students in STEM fields. CRED emerges as a promising solution, offering culturally relevant methodologies to bridge these gaps.

2.6. Culturally Relevant Engineering Design (CRED)

CRED involves integrating students' cultural identities and community experiences into STEM education. By making STEM curricula more relatable and meaningful, CRED aims to enhance engagement and academic outcomes. Manuel et al. (2023) demonstrate that culturally responsive pedagogies improve students' sense of belonging, motivation, and participation in STEM activities.

2.7. Principles of CRED

2.7.1. Key principles of CRED include:

- Designing curricula that reflect cultural diversity.
- Incorporating culturally relevant examples, narratives, and contexts.
- Providing opportunities for students to connect STEM concepts with their heritage.

Bowman et al. (2022) and Gay (2018) highlight the importance of embedding cultural relevance in teaching strategies to foster inclusion, empathy, and active learning. Such approaches not only improve engagement but also promote critical thinking and collaboration among students.

2.8. Findings from Existing Research

Several studies support the efficacy of culturally responsive practices in STEM education. Casler-Failing et al. (2021) identify CRED as a key strategy for sparking interest in STEM among middle school students. Hussar and Bailey (2017) critique traditional standards-based curricula for failing to address students' diverse needs, advocating for culturally responsive approaches instead. Spang and Bang (2014) further emphasize the role of culture in shaping learning, problem-solving, and understanding the world.

2.9. Summary

Existing research underscores the potential of CRED to transform STEM education by addressing issues of disengagement and fostering inclusivity. However, gaps remain in understanding its broader impacts, particularly in diverse classroom settings. This study seeks to build on these findings by comparing engagement levels between students exposed to CRED and those in traditional STEM classrooms. The results aim to provide actionable insights for educators and policymakers to enhance STEM education through culturally responsive practices.

3. Methodology

The research investigates how culturally relevant engineering design (CRED) impacts student engagement in STEM subjects, focusing on elementary school pupils in Nigeria. It seeks to address declining interest in STEM through innovative, culturally tailored teaching approaches.

3.1. Key Research Questions

- Can CRED principles enhance student engagement and interest in STEM?
- How do teaching methods and curricula influence student engagement?

3.2. Study Population

Participants include 4th-6th grade pupils (ages 8-11) of diverse socioeconomic and ethnic backgrounds, ensuring representation across gender, income levels, and cultural groups.

3.3. Intervention

An 8-week program integrates CRED projects into the STEM curriculum. Phases include:

- Pre-Intervention Assessment (Week 1): Surveys and educator interviews to establish baseline engagement and teaching methods.
- Intervention Implementation (Weeks 3-5): Hands-on CRED projects highlighting cultural relevance; comparison between traditional and CRED classrooms.
- Post-Intervention Evaluation (Weeks 6-8): Post-surveys, interviews, and data analysis to measure changes in engagement.

3.4. Data Collection

- Quantitative: Surveys, attendance records, academic performance.
- Qualitative: Classroom observations, interviews with students and teachers, focus groups, and student artifacts.

3.5. Ethical Considerations

- Informed consent from participants and guardians.
- Ensured confidentiality and minimized participant risks.
- Measures to reduce researcher bias and ensure credibility.

3.6. Objectives

- Evaluate the effectiveness of CRED in boosting STEM engagement.
- Compare outcomes between traditional and CRED-based STEM classrooms.
- Inform future practices to create inclusive STEM education.

4. Quantitative data analysis procedures

4.1. A brief overview

This study aims to identify the relationship between culturally relevant engineering design (CRED) and students' perceptions and engagement in Science, Technology, Engineering, and Mathematics (STEM) classrooms. This study used qualitative and quantitative data collection procedures to answer research questions.

4.2. Quantitative Data Collection Procedures

4.2.1. Participants: Students

20 random students participated in this survey. These participants were made up of individuals from grades 8 – 12 in a STEM classroom.

4.3. Quantitative Instrument (6-point Likert-type scale survey)

The researcher surveyed and investigated the relationship between Culturally Relevant Engineering Design (CRED) and engagement in STEM classrooms. The motivation for this study stems from the importance of incorporating culturally relevant approaches to enhance student engagement and learning outcomes in STEM education. The project assessed two constructs: CRED and Engagement in STEM Classrooms. students were asked to rate their level of agreement on six questions using a 6-point Likert-type scale. The scale ranged from 1 to 6, with 6 representing "strongly agree," 5 representing "agree," 4 representing "slightly agree" (all indicating some form of agreement), 3 representing "slightly disagree," 2 representing "disagree," and 1 representing "strongly disagree" (all indicating some form of disagreement). Additionally, teachers were interviewed using six questions crafted before the interview began.

4.4. Design

This study utilized descriptive analysis and statistics to examine the level of agreement for individual items related to Culturally Relevant Engineering Design (CRED) and engagement in STEM classrooms. The aim was to understand participants' perceptions regarding CRED practices and their impact on student engagement. The study also calculated the correlation between CRED and engagement in STEM classrooms to explore potential relationships between these constructs.

4.5. Procedure

The study assessed two constructs: Culturally Relevant Engineering Design (CRED) and Engagement in STEM Classrooms. Participants responded to a series of interview questions and Likert-scale items measuring their agreement with statements related to CRED and engagement in STEM classrooms. Descriptive statistics were employed to describe the level of agreement for individual items within each construct. The mean scores for the items under each construct were calculated to represent the overall perception of CRED and engagement in STEM classrooms. Furthermore, the study computed the correlation between these mean scores to examine the relationship between CRED and engagement in STEM classrooms. Does it have negative or positive benefits, etc.?

5. Results

Table 1 displays the age and gender of the survey participants.

	Overall Sample **Count**	
Demographic Category	(*n* = 20)	%
Age		
8 years 9 years 10 years 11 years	4 4 8 4	20.0 20.0 40.0 20.0
Gender		
Male	60	60.0
Female	40	40.0

Table 2 displays some form of agreement with the provided statements under the constructs of Culturally Relevant Engineering Design (CRED) and Engagement in STEM Classrooms. The highest form of perception of CRED under C1 was q3, most participants feel more motivated to learn STEM topics through culturally relevant engineering design. The highest form of engagement in STEM learning under C2 was q5 and q6, showing that 100% of participants agree that they enjoy working on STEM projects and assignments and that STEM learning experiences make them feel excited and curious because of CRED teaching styles.

Table 2 Displays the Percentage of Some Form of Agreement for the Perception of CRED, and Engagement in STEM Learning.

Question		**% Some Form of Agreement**		**M**	**SD**
C1. Perceptions of Culturally Relevant Engineering Design (CRED)					
q1.	CRED enhances my understanding of STEM concepts	80.0		4.4	1.5
q2.	CRED makes STEM subjects more interesting to me	80.0		4.8	1.1
q3.	I feel more motivated to learn STEM topics through culturally relevant engineering design.	100.0		5.2	0.8
C2. Engagement in STEM Learning					
q4.	I actively participate in STEM activities during class	80.0		4.6	1.7
q5.	I enjoy working on STEM projects and assignments.	100.0		5.2	0.8
q6.	STEM learning experiences make me feel excited and curious.	100.0		4.8	0.8

The reliability and correlation for the constructs are shown in Table 3. The correlation between Perception of CRED, and Engagement in STEM learning was r = .65

Table 3 Displays Correlation of Subscale Constructs and Measures of Internal Consistency for Survey Data.

Construct Number	**Subscale Constructs**	**Question Numbers**	**C1.**	**A**
C1.	**Perceptions of CRED**	q1, q2, q3		.73
C2.	**Engagement in STEM Learning**	q4, q5, q6	.65	.86

p < .06

6. Discussion

The purpose of this study was to investigate how culturally relevant engineering design impacts students' perceptions and engagement in STEM (Science, Technology, Engineering, and Mathematics) classrooms. By investigating statistical correlations, we aim to understand the relationship between culturally tailored engineering activities and students' perceptions and engagement in STEM subjects. The study's findings suggest a positive relationship between Culturally Relevant Engineering Design (CRED) and engagement in STEM classrooms. The descriptive analysis provided insights into participants' perceptions of CRED practices and engagement levels, while the correlation analysis highlighted the association between these constructs. These findings underscore the importance of integrating culturally relevant approaches to enhance student engagement and promote inclusive STEM education practices. As displayed in the

results, the findings showed that students who perceive culturally relevant engineering design positively demonstrate higher levels of engagement in STEM learning.

6.1. How do my Findings fit back with the current Literature on the Subject?

According to the findings by Manuel et al. (2023), the integration of CRED pedagogical approaches into the STEM classroom will improve students' academic outcomes and STEM engagement and this aligns with the findings in the given survey. The present study investigated the authenticity and reliability of the findings of previous researchers on culturally responsive pedagogy that they believe will increase student engagement in STEM classrooms, and the findings from this work align perfectly with what was previously discovered about the CRED teaching styles to influence the student's engagement in the STEM classrooms positively.

6.2. Implications for Practice

With the information and data found in this study, STEM teachers can use this to decide to integrate CRED teaching styles, learning approaches, and CRED focus curriculum into their STEM classrooms. These findings underscore the importance of integrating culturally relevant approaches to enhance student engagement and promote inclusive STEM education practices.

7. Qualitative data analysis procedure

7.1. Data Collection

Interviews were conducted with 6 participants to gather qualitative data on their experiences integrating culturally relevant engineering design (CRED) principles into STEM classrooms.

7.1.1. Qualitative Instrument (Interview Questions)

The researcher interviewed to investigate the relationship between Culturally Relevant Engineering Design (CRED) and engagement in STEM classrooms. The 6 questions below were used for the interview. The responses to the questions below are listed in Appendix 2.

- Can you describe your experience integrating culturally relevant engineering design principles into your STEM classroom?
- How do you believe this approach impacts students' perceptions and engagement in the classroom?
- What aspects of culturally relevant engineering design have been most effective in capturing students' interest and increasing their engagement with STEM subjects?
- Could you provide examples of any observed differences in student engagement between classrooms that employ culturally relevant engineering design principles and those that follow a more traditional STEM curriculum?
- How do you adapt your teaching style and methods to incorporate culturally relevant engineering design principles?
- From your perspective, how do students respond to learning experiences that emphasize culturally relevant engineering design?

7.2. Procedures

7.2.1. Transcription

Data was collected (spoken language) and each collected data from each teacher interviewed was transcribed into written text using transcribed data software tools. This transcription software enabled the process to be faster, though human oversight was added to the transcription process to ensure accuracy. After the transcription process was completed, I moved to the coding stage.

7.2.2. Coding

In the coding stage, the transcribed data is read, and a label is assigned to a segment of data that captures the key idea or concept. Coding could be done using many methods, but this work used the open coding concept. An open coding process involves identifying significant statements and phrases and giving them a code label. The identified codes were then grouped into themes based on emerging categories and patterns.

7.2.3. Thematic Analysis

The codes were organized into broader themes and patterns. This was done by grouping codes into broader categories (one word or a phrase) that capture similar ideas or patterns.

7.2.4. Review and Refinement

Themes were reviewed and refined by cross-checking with the original data to ensure they accurately represented the participants' experiences. Direct quotes from the transcribed data do this to illustrate the theme's accuracy.

7.2.5. Triangulation

Data was cross-verified with multiple sources, including participants' feedback and field notes, to enhance the credibility of the findings.

7.3. Validity and Reliability

7.3.1. Validity

- Ensured by using triangulation and member checking, where participants reviewed the findings to confirm accuracy.
- Rich, thick descriptions were used to provide a detailed account of the context and participants' experiences.

7.3.2. Reliability

- Achieved through consistent data collection and analysis procedures.
- A code-recode strategy was used, where the data was coded, left for a period, and then recoded to check for consistency.
- Inter-coder reliability was ensured by having multiple researchers independently code the data and then compare and reconcile differences.

7.4. Presentation of Results

The results are organized into key themes identified through coding and thematic analysis. The findings are presented in tables to enhance readability and provide a clear overview of the data.

7.5. Descriptive Findings

Table 1 Codes and Themes

Codes	Themes
Time limitations	Challenges in implementing CRED
Curriculum adaptation	Challenges in implementing CRED
Student enthusiasm	Student engagement and perception
Hands-on-activities	Student engagement and perception
Cultural relevance	Student engagement and perception
Increased interest	Effective aspects of CRED
Collaborative tasks	Effective aspects of CRED
Cultural representations	Effective aspects of CRED
Engagement duration	Difference between CRED and traditional STEM
Cultural displays	Difference between CRED and traditional STEM
Cultural homework	Adaptation of teaching styles
Cultural projects	Adaptation of teaching styles

Positive reactions	Student responses to CRED
Improved Attitudes	Student response to CRED

In Table 1 above, 14 predetermined codes based on research questions were listed and identified from the transcribed data. By thematic analysis process, familiar codes were grouped into themes, and at the end, the 14 codes were grouped into 6 themes. After the theme stage, I moved into the write-up stage, where each theme was properly defined and explained. The explanation helps to make sense of the themes and helps to provide the answers that research questions were developed to answer.

Table 2 Key Findings

Themes	**Key Findings**
Challenges in implementing CRED	Time constraints and initial difficulty in adapting teaching techniques and curriculum.
Student engagement and perception	Increased enthusiasm and engagement, the relevance of STEM to students' lives, and an inclusive environment.
Effective Aspects of CRED	Hands-on learning, collaborative problem-solving, and cultural representation were highly effective.
Differences Between CRED and Traditional STEM	Greater interest and participation, enhanced sense of belonging in CRED classrooms.
Adaptation of Teaching Styles	Strategies included cultural homework, culturally relevant projects, and understanding students' backgrounds.
Student Responses to CRED	Positive reactions, motivation, enthusiasm, and improved attitudes towards STEM subjects

7.6. Descriptive Findings

7.6.1. Theme 1: Challenges in Implementing CRED

- Time Constraints: Limited classroom periods (35–40 minutes) made it difficult for teachers to conduct meaningful, hands-on activities required for CRED teaching.
- Initial Adaptation: Teachers faced challenges transitioning from traditional passive teaching to active learning styles integral to CRED. Professional development opportunities (e.g., workshops, conferences) were lacking, making it harder to adopt and implement CRED strategies effectively.

7.6.2. Theme 2: Student Engagement and Perceptions

- Increased Engagement: Students displayed heightened interest in STEM subjects through hands-on, culturally relevant, and collaborative learning activities.
- Cultural Relevance: Aligning STEM tasks with students' cultural backgrounds improved their connection to the material and fostered a sense of ownership over their learning.

7.6.3. Theme 3: Effective Aspects of CRED

- Hands-on Learning: Practical, real-world applications of STEM concepts helped students grasp abstract ideas and see the relevance to their lives and communities.
- Collaborative Problem-solving: Team-based tasks enhanced cooperation, respect, and a sense of community among students from diverse cultural backgrounds.

7.6.4. Theme 4: Differences Between CRED and Traditional STEM Classrooms

- Greater Interest and Participation: CRED classrooms saw increased student engagement and prolonged involvement in STEM activities.
- Sense of Belonging: Representing students' cultural identities created a supportive, inclusive environment where students felt valued and thrived.

7.6.5. Theme 5: Adaptation of Teaching Styles

- Cultural Homework: Assignments involving students' cultural histories provided teachers with insights into their backgrounds, enabling tailored and inclusive instruction.
- Culturally Relevant Projects: Projects that incorporated cultural elements helped students connect their learning to their lives, enhancing motivation and understanding of STEM concepts.

7.7. Theme 6: Student Responses to CRED

- Positive Reactions: Students showed enthusiasm and a stronger connection to the curriculum when their cultural identities were reflected.
- Improved Attitudes: CRED approaches significantly enhanced students' perceptions of STEM, increasing their interest, confidence, and academic performance.

8. Discussion and conclusion

8.1. Outcome Analysis

Each research question is addressed based on the data analysis outcomes.

8.1.1. Research Question 1: Challenges in CRED Implementation

The main challenge was the limited time for integrating CRED concepts due to the structured timetable. The school authorities will need to allocate more time for STEM activities and learning in the classrooms. Several innovative ideas will need to be designed by the teacher in collaboration with the school authorities to overcome the challenge of limited time for engaging the CRED activities in the classrooms.

8.1.2. Research Question 2: Impact on Student Engagement

CRED positively impacted student engagement and perceptions by making STEM subjects more relevant and relatable. This observation will go a long way towards retaining students and improving their interest in STEM subjects and activities.

8.1.3. Research Question 3: Effective Aspects of CRED

Hands-on learning and collaborative problem-solving were key in capturing students' interest. So teachers should focus on hands-on learning activities in the classroom since is proportional to improved students' perception and interest in STEM learning.

8.1.4. Research Question 4: Differences in Engagement

Students in CRED classrooms showed higher interest and participation compared to traditional STEM classrooms. Therefore, it is important for teachers to regularly adopt CRED teaching styles, the CRED-focused curriculum, and other active learning approaches in STEM learning classrooms.

8.2. Learning Themes

- **Unexpected Outcomes**: The extent of students' improved interest in STEM using CRED pedagogy was greater than anticipated. This means the intervention resulted in an unexpected positive outcome. The CRED intervention designed to improve students' perception and interest yielded results that exceeded expectations. Originally, it was anticipated that students would experience an improved interest. However, the actual outcomes revealed a significantly greater improvement than predicted.
- **What Worked Well**: Hands-on activities and culturally relevant projects were particularly effective in enhancing students' learning experiences and sense of engagement. Hands-on activities offer the opportunity for students' active engagement, practical skills, collaborative skills, and critical thinking. Also, the CRED project incorporates elements of students' culture, and these made learning material more relatable and meaningful. Students showed greater interest and enthusiasm when working on projects that reflected their personal experiences and identities. Culturally relevant projects fostered a sense of respect and inclusion, as students saw their cultures represented and valued in the curriculum. These projects exposed all students to diverse cultures and perspectives, promoting empathy and understanding within the classroom.
- **What Worked Less Well**: Time constraints remained a significant hurdle. Time constraints remained a significant hurdle, impacting the overall effectiveness of certain aspects of the program. Limited time affects

the depth of learning. Due to tight schedules, some activities had to be rushed, preventing students from fully exploring and understanding the material. In some cases, students were unable to complete projects to their full potential due to limited time, thereby leading to a sense of frustration and unfinished learning experiences.

- **Process Changes**: Future implementations could benefit from more flexible scheduling to allow deeper engagement with CRED concepts. The STEM education department should negotiate for **extended project timelines and longer duration.** Allocating more time for hands-on activities and culturally relevant projects would enable students to explore concepts in greater depth and complete their projects more thoroughly. Introducing staggered deadlines can help manage the workload and reduce stress for both students and teachers. Allowing flexibility in the curriculum to incorporate CRED concepts more seamlessly can help maintain a balance between standard curriculum requirements and innovative projects. Adopting block scheduling for CRED will be another creative innovation for CRED activities. Implementing dedicated block scheduling where larger chunks of time are dedicated to CRED projects can facilitate deeper engagement and reduce the pressure of time constraints. Another way to buy time for CRED projects is by integrating thematic units into STEM learning. Organizing the curriculum into thematic units that span several weeks can allow for continuous and cohesive exploration of CRED concepts. There may be a need for enhanced support structures and resources in CRED STEM classrooms. Providing additional resources such as teaching assistants or peer mentors can help manage the increased demands on time and provide more personalized support to students. Offering professional development for teachers on managing flexible schedules and integrating CRED concepts can enhance the effectiveness of these initiatives. Also, involving students in the CRED project planning process can help identify the most effective ways to allocate time and ensure that the projects are engaging and meaningful to them. Finally, collecting and incorporating regular feedback from students can help fine-tune the scheduling and implementation process. By adopting these process changes, future implementations can better accommodate the time needed for hands-on activities and culturally relevant projects, thereby maximizing their positive impact on student's learning experiences and sense of belonging.

8.3. Implications for Practice

8.3.1. Improving Teacher's Professional Practice

Teachers should incorporate cultural elements into their curriculum to enhance student engagement. The following strategies can be used to improve professional practice by the teacher in the CRED STEM classroom. They include:

8.3.2. Culturally Relevant Content

- **Diverse Perspectives:** Literature, historical examples, and case studies from various cultures will provide students with a broader understanding of the subject matter.
- **Local Culture:** it is good to Integrate local cultural elements and community resources to make learning more relevant and relatable for students.

8.3.3. Cultural Celebrations and Events

- **Cultural Days:** The teacher should organize events or days dedicated to celebrating different cultures, where students can share their traditions, food, music, and art.
- **Guest Speakers:** the teacher can Invite guest speakers from diverse cultural backgrounds to share their experiences and knowledge with students.

8.3.4. Inclusive Curriculum Design

- **Collaborative Projects:** the teacher should encourage the design of projects that encourage students to work in a team, and explore and present their cultural backgrounds, fostering a sense of pride and belonging.
- **Multicultural Materials**: the teacher should adopt and use textbooks, visual aids, and digital resources that reflect diverse cultures and experiences.

8.3.5. Professional Development

- **Cultural Competency Training:** the teacher from time to time should be provided with training on cultural competency and inclusive teaching practices to help them effectively integrate cultural elements into their curriculum.
- **Peer Collaboration:** the teacher will be encouraged to collaborate and share best practices for incorporating cultural elements in their lessons.

8.3.6. Student Involvement

- **Student Input**: the teacher should always seek input from students about their cultural backgrounds and interests, and incorporate these into lesson plans and projects.
- **Student-led Activities**: the teacher should empower students to lead activities or discussions related to their cultures, enhancing their leadership skills and engagement.

8.3.7. Classroom Environment

- **Cultural Artifacts:** the teacher should decorate the classroom with cultural artifacts, posters, and displays that reflect the diversity of the student body.
- **Inclusive Policies:** Implement classroom policies that respect and celebrate cultural differences, creating an inclusive and supportive environment for all students.

Incorporating the strategies listed above, teachers will create a more inclusive and engaging learning environment that values and reflects the diverse cultural backgrounds of their students. This approach will enhance student engagement and promote empathy, respect, and a deeper understanding of the world**.**

8.4. Next Steps

Further research should focus on identifying effective strategies to mitigate the time constraints faced by educators when implementing Culturally Relevant Education (CRED) practices. This could include exploring flexible scheduling options, integrating CRED principles into existing curricula, and utilizing collaborative teaching models. Additionally, longitudinal studies are necessary to evaluate the long-term impacts of CRED on student outcomes, such as academic performance, social-emotional development, and overall engagement. Understanding these long-term effects will provide valuable insights into the sustained benefits of CRED and inform best practices for its implementation in diverse educational settings.

8.5. Future Research

Further research should investigate the scalability of Culturally Relevant Education (CRED) principles across various educational contexts and subjects. This includes examining how CRED can be adapted and effectively implemented in diverse school environments, from urban to rural settings, and across different grade levels. Additionally, it is important to explore how CRED principles can be integrated into a wide range of subjects, including STEM, humanities, and the arts. Such research will help identify the best practices and potential challenges in scaling CRED, ensuring that it can be broadly applied to benefit all students, regardless of their background or the subject matter being taught.

9. Conclusion

The study highlights the positive impact of CRED on student engagement and perceptions in STEM education. Despite challenges like time constraints, incorporating cultural elements into the curriculum enhances relevance and inclusivity. The findings suggest that further refinement and support for teachers could optimize the integration of CRED principles, promoting a more equitable and engaging learning environment for all students.

Compliance with ethical standards

Statement of ethical approval

Ethical approval was obtained.

Statement of informed consent

Informed consent from participants and guardians.

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