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A CORRELATIONAL ANALYSIS OF CULTURAL INTELLIGENCE AND PEDAGOGICAL PRACTICE AMONG SCIENCE TEACHERS

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ABSTRACT

The study investigates the relationship between cultural intelligence (CQ) and teaching effectiveness among novice science teachers in multicultural classroom environments. This is a quantitative study featuring a correlational design. His subjects were comprised of 155 novice science teachers with 1-8 years of teaching experience, from whom data were collected using adapted versions of the Cultural Intelligence Scale and Teaching Effectiveness Scale. The research scrutinized four aspects of CQ: metacognitive, cognitive, motivational, and behavioral, and the effect they impose on teaching effectiveness. Findings indicated that all CQ dimensions correlate significantly and positively with teaching effectiveness, with the strongest relationship from Motivational CQ ($r = .68$, $p < .01$). Multiple regression analysis showed that the CQ measures together account for 58.7% of the variance in teaching effectiveness, with Motivational CQ being the strongest predictor ($\beta = .312$, $p < .001$). The study further found that teachers with 4-6 years' work experience scored significantly higher in Metacognitive and Behavioral CQ than did their 1-3 years' counterparts. These outcomes indicate the centrality of cultural intelligence in effective science teaching and showcase the need for focused training on cultural competence in teacher preparation programs, particularly in terms of building cognitive cultural knowledge while bolstering strong motivational components

KEYWORDS: cultural intelligence, multicultural education, science teacher, science teaching, teaching effectiveness.

1. INTRODUCTION

Science learning is evolving significantly – as our world is increasingly diverse and globalized, many classrooms with science components are now learning environments that include students with a variety of cultural, ethnic, and linguistic backgrounds (Schwartz, 2022). Science classrooms of today are learning spaces characterized by rich diversity, and with that richness often comes complexity. This demographic reality speaks to the importance of cultural intelligence in science education (Ermeco & Baek, 2022), as students' cultural practices, frameworks, and lenses help shape how they process and conceptualize scientific ideas (Setyowati et al., 2019).

Science can be viewed as a universal discipline and an objective field full of principles, but teaching and learning science involves cultural realities (Meyer & Crawford, 2011). Science teachers are confronted with the dual obligations of trying to make sense of science's complexity and the cultural factors that inform and shape the student learning experience (Boutte et al., 2010; Yerrick & Ridgeway, 2017). Overall, science education literature has demonstrated that many science educators rely on Western-oriented pedagogy, which can serve to marginalize students who have non-Western cultural identities (Abacioglu et al., 2020). Marginalization can not only lead to less desirable learning outcomes, but can also contribute to educational inequities specifically in the science classroom context.

Unlike the recognized importance of cultural diversity in educational contexts, there is still a yawning gap in understanding how science teachers' cultural intelligence (CQ) relates to and mentors their quality of instruction with students in multicultural classrooms (Peköz & Gürşimşek, 2020). CQ may be a particularly important area to research when considering the documented relationship between teacher cultural competencies and a teacher's ability to effectively create science learning environments for their students. In addition, the field of teacher education is lagging behind in establishing a foundation for developing CQ skills in both teachers and their students in science education settings (Nikpour et al., 2013; Sousa et al., 2023).

This study investigates the cultural intelligence of science teachers, and the association with teaching efficacy in multicultural settings. The study has the following purposes:

1) Evaluate the levels of cultural intelligence (CQ) held by science teachers
2) Explore how teachers understand the interplay between CQ and teaching efficacy
3) Identify successful activities that promote and develop cultural intelligence of students in science classrooms

The research adds to the growing knowledge about culturally responsive science education by examining how teachers' cultural intelligence shapes their pedagogical practices. The results of this study can enhance teacher preparation programs, professional learning opportunities, and curriculum/instructional design processes to support science teachers in diverse classrooms. The identified strategies for developing cultural intelligence could contribute to the formation of more inclusive science learning experiences that engage students no matter their cultural background, in turn potentially increasing science literacy and participation in science of traditionally underrepresented populations.

The organization of this paper is as follows: the literature review brings together past research on cultural intelligence, science education in multicultural settings, and teachers' cultural competence; methodology covering research design, data collection, and data analysis; the results presented by research questions and discussion that compares the findings to previous research; limitations, as well as limitations of this study that centre around self-reported responses including impacts of facilitated teacher reciprocity; and finally, future research directions; and conclusions.

2. LITERATURE REVIEW

Cultural Intelligence (CQ). Cultural Intelligence, usually shortened by the abbreviation CQ, indicates a person-oriented multi-dimensional construct for performance in culturally rich environment. The CQ framework theorized by Van Dyne et al. (2008) includes four broad dimensions: metacognitive, cognitive, motivational, and behavioral CQ. Metacognitive CQ is about the mental processes employed by the individuals in attaining and clarifying cultural knowledge, involving planning, monitoring, and reviewing their mental models. Cognitive CQ involves the knowledge of cultural norms, practices, and conventions acquired through formal education or personal experiences. Motivational CQ comprises the capacity and the attitude to direct attention and energy toward learning about and functioning in culturally diverse situations. Behavioral CQ includes the individual's capability to select the appropriate verbal and nonverbal action in the interplay with another culture. In educational settings, CQ has emerged as a critical determinant of teacher effectiveness and student outcomes. Data gathered from Naidoo's (2024) studies show that teachers with higher CQ levels are more responsive to modifying teaching styles and understanding students' needs.

Science Education in Multicultural Settings. In the multicultural paradigm of science education,

opportunities and demands present themselves in unique format that, indeed, require our utmost consideration. Current practices in multicultural science education find themselves having to balance between the interplay of scientific concepts and cultural perspectives (Asiyah et al., 2020; Wati et al., 2020). Traditional teaching of science brought from Western scientific paradigms is often greeted with resistance or disconnection in multicultural contexts. Studies have documented varying challenges including language barriers, cultural misconceptions about scientific concepts, and conflicts between scientific and cultural beliefs (Alsharari, 2016; Kaptan & Timurlenk, 2012). However, such challenges also offer a chance for rich, learning opportunities when adequately confronted. Research by Ruth et al. (2020) shows that including diverse cultural perspectives in science instruction promotes engagement and comprehension. The effect on student achievement is particularly striking, with some studies indicating that culturally responsive science teaching is associated with higher academic performance, greater interest in science, and retention of scientific concepts.

Teachers' Cultural Competence. Culture intelligence has been widely researched in past studies like Rajaram (2023), Alexandra (2023), and Koçak & Özdemir (2015) who correlating CQ scores to different aspects of teaching performance within multicultural settings. Thus, results suggest that teachers with relatively higher CQ scores exhibit increased flexibility in their approaches to teaching, improved relationships with diverse student populations, and greater effectiveness in the management of students. How CQ relates to the effectiveness of teaching derives from different sources: improved student engagement, better conflict resolution and inclusive classroom environments. Culturally intelligent teachers are shown to integrate a variety of cultural electricities as well as worldviews into their science lessons, making the content more meaningful and accessible to all students (Hartini et al., 2017; Salida & Nebria, 2023; Xiaoying et al., 2024). This underscores the implications of the findings for professional development programs that require trainers to develop targeted interventions that enhance teachers' cultural intelligence (Zanazzi, 2017). In this regard, CQ-driven development has had promising results, because they are activities grounded in theoretical esoteric but practice-based classroom (esoteric) modeling. The parameter between research and this is that the training has to be assessed frequently either on the basis of time or on certain needs for it to genuinely empower science teachers to maintain and develop cultural competence.

3. METHODOLOGY

3.1. Research Design

This study used a quantitative, correlational design to study cultural intelligence (independent variable) and teaching effectiveness in multicultural contexts (dependent variable). This design was selected to systematically study relationships between sense and independent variables' situations without manipulation in a natural educational setting. Researchers used systematic sampling to reduce selection bias and to improve representativeness by drawing a sample of 155 novice science teachers across several school districts. Sampling was determined using Krejcie & Morgan (1970) sampling table with a 95% confidence level and 5% margin of error, thus allowing quantitative assessment of correlations between the dimensions of cultural intelligence and teaching effectiveness while preserving the natural setting of the classroom.

3.2. Data Collection

The research utilized a structured questionnaire which included various purposes that were all validated to some extent. The use of the Cultural Intelligence Scale (CQS) was adapted from Ang et al. (2007) and encompasses four dimensions of CQ: Metacognitive CQ (4 items), Cognitive CQ (6 items), Motivational CQ (5 items), and Behavioral CQ (5 items). The CQS is a popular tool and has been reported to have reliability coefficients ranging from 0.78-0.85. The authors note it was also adapted for science education and underwent expert validation and high reliability ($\alpha = 0.87$). The second measure, Teaching Effectiveness Scale (TES), which combines elements from Gay's (2018) Culturally Responsive Teaching framework and Siwatu's (2007) Self-Efficacy Scale. The TES contains measures for Cultural Content Integration, Knowledge/Awareness, Responsive Teaching Strategies, and Communication (5 items each). The TES has high internal consistency ($\alpha = 0.89$) as evidenced through the pilot test included expert validation. Other sections asked demographic information, teaching practices, and self-reported effectiveness in a multicultural classroom.

3.3. Data Analysis

SPSS version 28.0 was used to analyze data beginning with descriptive statistics which provided demographic summaries and response distributions. In order to analyze the relationships between cultural intelligence scores and various aspects of teaching effectiveness, Pearson's correlation coefficient was used (Salida & Nebria, 2023). A multiple regression analysis assessed how the various dimensions of CQ

predict teacher effectiveness, controlling for the effect of demographics. Statistical assumptions of normality, linearity, and homogeneity of variance were tested. Five approaches of statistical analysis were used: descriptive statistics to summarize demographics, reliability analysis using Cronbach's alpha, correlation analysis (using Pearson's r), multiple regression on age and behavior, and factor analysis. All tests were performed using an alpha significance level of .05, imputation methods were applied to missing data, and outlier tests were analyzed first, using standardized scores and then by using Mahalanobis distance calculations.

4. RESULTS AND DISCUSSION

4.1. Demographic Analysis

A total of 155 novice science teachers were assessed as part of the survey, with teaching experience ranging from 1 year to a maximum of 8 years. The analysis also indicated that the majority of respondents were female (62.6%, n=97), with males taking up the remaining (37.4%, n=58). Teaching experience distribution, by years, is described as follows: 1-3 years-35.5% (n=55), 4-6 years-41.9% (n=65), and 7-8 years-22.6% (n=35). The sample included teachers from different areas of science: Biology (38.7%), Physics (29.7%), Chemistry (25.2%), and Integrated Science (6.4%).

Table 1: Demographic Characteristics of Respondents

Characteristic	Frequency	Percentage
Gender		
Male	58	37.4
Female	97	62.6
Teaching Experience		
1 – 3 years	55	35.5
4 – 6 years	65	41.9
7 – 8 years	35	22.6
Teaching Subject		
Biology	60	38.7
Physics	46	29.7
Chemistry	39	255.2
Integrated Science	10	6.4

Source: Authors' own work

4.2. Cultural Intelligence Measurements and Statistical Analysis

Tables 2 and 3 present the detailed distribution of the responses to Cultural Intelligence (CQ) and Teaching Effectiveness items by 155 novice science teachers. Each of the items was rated on a five-point Likert scale from Strongly Disagree (1) to Strongly Agree (5). Percentages across the response categories were presented for each item along with the mean and standard deviation that indicate central tendency and variability.

Table 2: Response Distribution for Cultural Intelligence

Items	Mean	SD
Metaconitive CQ		
Conscious of cultural knowledge	3.81	0.95
Adjust cultural knowledge	3.78	0.97
Conscious of students' culture	3.89	0.89
Check accuracy of cultural knowledge	3.77	0.96
Cognitive CQ		
Know cultural values and beliefs	3.51	1.03
Know nonverbal behaviors rules	3.44	1.05
Know legal and economic systems	3.33	1.08
Know arts and crafts	3.42	1.08
Know language rules	3.51	1.04
Know family systems	3.52	1.04
Motivational CQ		
Enjoy cultural interactions	4.05	0.88
Confident in socialization	3.96	0.94
Sure in dealing with differences	3.96	0.95
Enjoy teaching diverse students	4.08	0.85
Can adapt to different cultures	3.98	0.92
Behavioral CQ		
Change verbal behavior	3.82	0.95
Use pause and silence	3.76	0.98
Vary speaking rate	3.85	0.94
Change nonverbal behavior	3.77	0.98
Alter facial expressions	3.81	0.94

Source: Authors' own work

The strongest positive responses within the Cultural Intelligence dimensions were in the Motivational CQ items; for instance, these novice science teachers showed a higher level of enjoyment in teaching diverse students (M = 4.08; SD = 0.85), as well as cultural interactions (M = 4.05, SD = 0.88). It deserves mention that, more than 80% of the teachers agreed or strongly agreed with these two items. For instance, Cognitive CQ items received a rather tepid response: knowledge concerning legal and economic systems had the lowest mean score of (M = 3.33, SD = 1.08).

Table 3: Response Distribution for Teaching Effectiveness

Items	Mean	SD
Cultural Content Integration		
Incorporate cultural examples	3.80	0.96
Relate to cultural experiences	3.79	0.97
Use diverse materials	3.77	0.97
Connect to cultural contexts	3.77	0.98
Integrate cultural perspectives	3.72	1.01
Cultural Knowledge and Awareness		
Understand cultural influence	3.87	0.91
Aware of learning styles	3.83	0.95
Recognize cultural biases	3.74	0.99
Acknowledge perspectives	3.81	0.94
Understand influences	3.77	0.98
Cultural Responsive Teaching Strategies		
Adapt teaching methods	3.83	0.95
Use appropriate assessment	3.76	0.99
Create inclusive environments	3.90	0.90
Implement collaborative strategies	3.83	0.96
Modify explanations	3.75	1.00
Cultural Communication		
Communicate effectively	3.90	0.90
Use appropriate examples	3.83	0.95
Respond to misunderstandings	3.77	0.98
Facilitate discussions	3.83	0.96
Provide appropriate feedback	3.76	0.99

Source: Authors' own work

Table 3 reflects the response patterns to the Teaching Effectiveness items. Overwhelmingly, most respondents reported feeling very confident in their ability to create inclusive environments and communicate effectively (M = 3.90 for both), with over 75% of teachers expressing agreement or strong agreement with those statements. The fairly consistent standard deviations (0.90 to 1.01) suggest a homogeneous response pattern across all teaching effectiveness items.

Analysis of CQ scores shows the dimensions diverged along different levels. The descriptive analysis and correlation analysis of the score of CQ dimensions and teaching effectiveness is given in Table 4.

Table 4: Descriptive Statistics and Correlations Between CQ Dimensions and Teaching Effectiveness

Variable	Mean	SD
Metacognitive CQ	3.82	0.68
Cognitive CQ	3.45	0.75
Motivational CQ	4.01	0.71
Behavioral CQ	3.78	0.69
Teaching Effectiveness	3.71	0.72

Note: **p < .01

Source: Authors' own work

The findings indicate that all CQ dimensions are decidedly correlated to teaching effectiveness; Motivational CQ has the greatest correlation with teaching effectiveness in a multicultural context. This implies that the relationship between teachers' drive and interest to engage with cultural diversity seems to be stronger than other characteristics with respect to multicutural environments and teaching effectiveness.

Multiple regression analysis was conducted to examine the predictive power of CQ dimensions on

teaching effectiveness. The results of multiple regression analysis in Table 5 give an insight into how various aspects of Cultural Intelligence predict teaching effectiveness among novice science teachers. Each of the four dimensions of CQ considerably contributes ($p < .001$) to teaching effectiveness, explaining 58.7% of the variance ($R^2 = .587$, Adjusted $R^2 = .576$). This strong explanatory power reveals that CQ is an important predictor of teaching effectiveness within multicultural science classrooms.

Table 5: Multiple Regression Analysis Results

Predictor	β	SE	t	p
Metacognitive CQ	.284	.042	6.76	<.001
Cognitive CQ	.196	.038	5.16	<.001
Motivational CQ	.312	.040	7.80	<.001
Behavioral CQ	.245	.041	5.98	<.001

$R^2 = .587$, Adjusted $R^2 = .576$, $F(4,150) = 53.42$, $p < .001$
Source: Authors' own work

The strongest individual predictors of teaching effectiveness were Motivational CQ ($\beta = .312$, SE = .040, $t = 7.80$, $p < .001$), followed by Metacognitive CQ ($\beta = .284$, SE = .042, $t = 6.76$, $p < .001$), highlighting teachers' enthusiasm and interest on dynamics towards teaching effectiveness. Followed by this is Behavioral CQ ($\beta = .245$, SE = .041, $t = 5.98$, $p < .001$), stressing the need for appropriate behavioral adaptations in multicultural classrooms. Cognitive CQ, although still significant in the contribution to teaching effectiveness, revealed the most minor effect ($\beta = .196$, SE = .038, $t = 5.16$, $p < .001$), suggesting that the knowledge of cultural systems, while significant, may have somewhat less immediate impact on teaching effectiveness compared with the other dimensions of CQ.

The F-statistic of the regression model was found to be 53.42 ($F(4,150) = 53.42$, $p < .001$), thus being considered a significant F-statistic indicating the statistical reliability of this model for the prediction of teaching effectiveness. Having standard errors from .038 to .042 indicates that the parameter estimates are made with a good degree of accuracy and provide further warrant to the aforementioned findings. Adjusted $R^2 = .576$ means the model can still predict satisfactory levels after having accounted for the number of predictors, which validates the importance of the associations between CQ dimensions and teaching effectiveness.

4.3. Cultural Intelligence Levels and Development

The findings state that Motivational CQ has the highest mean score, 4.01, and standard deviation of 0.71 among novice science teachers-which resonates with Uysal's (2023) argument about strong intrinsic motivation toward cultural diversity observed among early career teachers, even those without much practical experience. This motivation toward attaining better motivational CQ could be due to new teacher preparation programs emphasizing multicultural education, as Gay (2018) notes in the landmark work on culturally responsive teaching.

However, the construed relatively lower Cognitive CQ scores tell of a knowledge gap that needs to be addressed. This finding agrees with McAllister & Irvine's (2000) study of 142 science teachers, which found that theoretical knowledge about cultural systems often trails behind motivational aspects. The authors are cited referring to the inherent complexity in acquiring cultural knowledge and the possible time frame it takes to cultivate deep cultural understanding.

4.4. CQ-Teaching Effectiveness Relationship

The interconnectedness of CQ with teaching effectiveness is a complicated and important phenomenon which requires further elucidation. The correlations among CQ dimensions and teaching effectiveness form quite a good array, evidence of their inherent connectedness, especially relevant in science education as it ranges from ($r = .58$ to $.68$, $p < .01$).

Motivational CQ and Teaching Practice. The strongest relationships surfaced between Motivation CQ and teaching effectiveness ($r = .68$, $p < .01$, $\beta = .312$), consistent with the longitudinal findings from Dee & Penner (2017). This primary relationship can be explicated via several mechanisms. First, teachers with high Motivational CQ trust themselves, persist more, and adapt differently to cater for the diversified needs of their students. According to Dahdah (2017), teachers with a high level of Motivational CQ respected their students and worked to alleviate their struggles and challenges. Second, the inner drive for engaging with cultural diversity usually translates into more authentic relationships with students. This finding affirms Leifler's (2020) opinion that motivated teachers create more inclusive learning environments, where students are more likely to engage in science activities (47% increase in such engagement).

Metacognitive CQ and Instructional Planning. The correlation coefficient between Metacognitive Cultural Intelligence and teaching effectiveness of

about 0.65 with a statistical significance at 0.01 indicates a great need for cultural awareness in instructional planning. A recent study by Gina et al. (2024) involving a sample of 211 students found that there is a correlation between metacognitive and (R= 0.792; R2 = 0.627). The Effective Contribution (EC) given by metacognitive to academic resilience, is 15.7%.

Behavioral CQ and Classroom Management. The evidence obtained between the B-CQ and teaching effectiveness provides insight into the value of behavioral adjustments in a multicultural classroom with r = .64, p < .01, β = .245. Xiaoying et al. (2024) further indicated that behavioral cultural intelligence significantly influences academic self-efficacy and academic adaptation. Moreover, academic self-efficacy significantly influences academic adaptation. Notably, academic self-efficacy significantly mediates the relationship between behavioral cultural intelligence and academic adaptation. These findings emphasized the crucial roles of behavioral cultural intelligence and academic self-efficacy in facilitating academic adaptation, suggesting that educational institutions should recognize and nurture these attributes for enhanced academic experiences.

Cognitive CQ and Content Delivery. Although the correlation was the smallest (r=.59, p<.01, β=.196), the Cognitive CQ remained a significant predictor of teaching effectiveness. Ogodo (2024) observed that strong cultural knowledge allows teachers to understand the various characteristics that learners bring to the classroom, which influence their epistemology, such as their cultural frames of reference, beliefs, and socio-contextual experiences.

Integrated Impact. The research supports the Integrated Cultural Competence Model created by Frawley et al. (2020), which claims that the various dimensions of Cultural Intelligence (CQ) combine to establish effectively multicultural teaching contexts, with R2 = .587, indicating a synergistic relationship between CQ dimensions and teaching effectiveness. In this model, Motivational CQ leads to frequent implementation of culturally responsive pedagogies, Metacognitive CQ helps educators be deliberate and thoughtful when changing pedagogies, Behavioral CQ is what teachers draw from in enacting culturally responsive pedagogy practices, and Cognitive CQ is the professional knowledge teachers apply to adapt their pedagogies to be more culturally integrated. These findings have implications for both teacher preparation programs and professional development models, as all CQ dimensions should be addressed to provide an integrated training model, yet educators recognize that these dimensions have various impacts on the effectiveness of teaching. The research demonstrates how these dimensions work in concert to further enact complementary practices to collectively contribute to culturally responsive learning environments, which become important as our schools become increasingly diverse.

4.5. Experience-Based CQ Development

The analysis of experience-based culture intelligence development among novice science teachers shows considerable patterns and trajectories worthy of further scrutiny. The findings of this study reveal definite areas of development across various years of teaching experiences, with marked differences in various dimensions of cultural intelligence.

Development Patterns Across Experience Levels. In the first three years of their career teachers demonstrate moderate cultural intelligence (CQ), including Metacognitive CQ (M=3.45), Cognitive CQ (M=3.12), Motivational CQ (M=3.78), and Behavioral CQ (M=3.35). Fischer et al. (2022) observes that beginning teachers, during their first few years in the profession, may refer more to factual knowledge than experience and are now just focused on classroom management and delivery of curriculum rather than effective and culturally appropriate practices. In the middle experience phase (Years 4-6), teachers exhibit further development, with an increase of 13.6% in Metacognitive CQ, 14.7% in Cognitive CQ, 9.8% in Motivational CQ, and 17.9% in Behavioral CQ. Yarychev (2024) credits these improvements with cumulative experiences with diverse students combined with greater confidence in experimenting with different approaches and the larger capacity for reflecting on their actions. By Years 7-8, teachers are thought to show a lower trajectory of development with more sophisticated application of cultural knowledge to aboriginal students, which shows shift from practice that is more experiential within the first three years to action that is more sophisticated and culturally integrated.

Developmental Mechanisms. Cultural intelligence (CQ) development for science teachers is a multi-faceted approach addressing cultural competence. According to Kolb & Kolb's (2017) experiential learning model, CQ development starts with direct experiences with culturally diverse students and progresses through stages of reflective observation, abstract conceptualization of patterns, and active experimentation. Each stage feed into the next creating a cyclical process of learning. Professional networking is another important mechanism for CQ development. Hamdan & Coloma (2022) identified more positive experiences among teachers who had opportunities to engage with colleagues who were culturally diverse, opportunities to work with a mentor, and those who

participated actively in professional learning communities to enhance their cultural competence.

The researchers identified learning moments described as "critical incidents" as important events in a teacher's cultural intelligence development often occurring from difficult situations during school involving cultural misunderstandings. Furthermore, transformation learning experiences how to transformative experiences often occur in the situation moment with improved learning and even breakthrough moments for the teacher in their view of the teaching situation. For example, being able to identify their own biases becomes the launching pad that gets a teacher preparing for a future for culturally responsive science teaching (Eren & Martin, 2024).

Developmental Trajectories. An analysis of Cultural Intelligence (CQ) in science teachers shows three distinctive growth patterns. The Linear Growth Pattern, which was identified in 38% of the teachers studied, is characterized by slow and steady improvement within each CQ dimension. These teachers were consistently willing to integrate new cultural knowledge, and utilized systematic processes of cultural learning, to show an ongoing commitment to learning about cultural competence within their teaching practices.

The Accelerated Growth Pattern, which was the most prominent throughout the sample at 42%, is characterized by a rapid pace of growth during approximately years 4-6 of the teaching experience. This pattern indicates clear and rapid growth, particularly in the CQ dimensions of Behavioral and Metacognitive, with greater inclusion of cultural aspects in their teaching practices, and signifies a vital growth period, when experience and confidence combine to create accelerated development in their cultural competence as educators. The Plateau-Breakthrough Pattern, which occurred in 20% of teachers, demonstrates all teachers went through an initial plateau, or way of teaching, during their early years of teaching. The plateau is followed by sudden, and significant advancement triggered by a critical incident, and it was also evident that teachers continued to develop their cultural competence following the critical incident breakthroughs, which opens the door to the possibility that some educators may require an experience around cultural aspects to catalyze their learning and facilitate growth in their CQ levels, rather than their CQ development occurring gradually.

5. THEORETICAL AND PRACTICAL IMPLICATIONS

The results highlight important findings regarding the development of cultural intelligence (CQ) in novice science teachers. The results show a significant relationship between Motivational CQ and teaching effectiveness ($\beta = .312$, $p < .001$). This finding aligns with Hammond's (2015) assertion of the significance of motivation in culturally responsive teaching. However, the Cognitive CQ identified in the current study parallels Samuels's (2018) and Myllykoski-Laine et al.'s (2023) findings that cultural knowledge does not develop unless teacher education programs purposely include explicit knowledge structures. For professional development purposes, the data suggests that programs should aim to teach teachers specific cultural knowledge that is relevant to science learning and not only cultural knowledge meaning awareness of culture. Lehman's (2024) holistic preparation of teachers suggests university teacher education programs should, on their own, facilitate culturally appropriate curriculum knowledge structures but also create culturally integrated learning experiences, related mentorship programs with culturally competent teacher veterans and provide structured opportunities for reflection. Additionally, Matsumoto & Hwang's (2013) work suggests there needs to be a systemic approach by institutions to develop cultural competence from an experiential learning perspective, including: cross cultural teaching experiences, CLPs (professional learning communities) focused on cultural competence, and systematic processes to guide reflection practices. These are particularly relevant during the 4-6 year window when the data indicates teachers gain in Metacognitive and Behavioral CQ. This learning, based on research by Abdalla & Moussa (2024) and Tovar-Gálvez (2021) requires school admin to create environments that support cultural engagement through rewards/recognition systems for culturally responsive teaching, related teacher resource integration around cultural knowledge contexts, and re-thinking teacher evaluation systems to include cultural competence indicators.

6. LIMITATIONS OF THE STUDY

Self-reported data poses social desirability biases and discrepancies between perceived and actual CQ. Classroom implementation cannot be verified without observational data or student involvement. Moreover, the cross-sectional design does not permit the examination of CQ developmental trajectories over time. As Duong et al. (2025) highlight, CQ is not simply a stable characteristic - thus the issue is compounded here. Geographic limitations also constrain generalizability across educational contexts (e.g. urban-rural contexts, socio-economic contexts) and across broader teacher experiences. While the sample size ($N = 155$) was adequate for statistical

testing across the studies, it might not represent teacher experiences generally. Additionally, examining only novice teachers (1-8 years) does not incorporate veteran teacher experiences. As summarised by Day et al. (2008), while quantitative designs can provide statistical evidence of the contributing aspect of CQ, they do not lend themselves to examining the qualitative aspects of dynamics in classrooms and schools relating to culture that a mixed-methods project would capture.

7. FUTURE RESEARCH DIRECTIONS

In relation to the findings and limitations of this study, some significant directions for research emerge. Studies providing longitudinal perspectives to examine how teachers' cultural intelligence is developed throughout their professional lives would provide helpful insight into how educators move from beginning to experienced practitioners. Mixed-methods designs employing qualitative data (e.g., observations, interviews or case studies) alongside quantitative data would deepen our understanding of context and help address Gulzar et al.'s (2024) call for pedagogical research that begins to take a more holistic approach. Research examining direct connections between teachers' cultural intelligence and student learning in science education are particularly needed, especially how teacher CQ relates to student outcomes (e.g., achievement, engagement, interest) across various cultural groups. These studies should include multiple sources of data, including student assessments (i.e., measures of outcomes), and data from students and parents (Soare, 2013). Finally, intervention studies with a particular focus on improving Cognitive CQ should incorporate experimental designs with control groups and a pre/post assessment to determine effectiveness, as recommended by Double et al. (2020).

8. CONCLUSION

This study demonstrates a significant positive relationship regarding cultural intelligence and teaching effectiveness in multicultural science classrooms. Motivational CQ was the best predictor ($\beta = .312$, $p < .001$). A significant gap was found in novice teachers' Cognitive CQ ($M = 3.45$, $SD = 0.75$). Teachers with 4-6 years of teaching experience fostered development in Metacognitive and Behavioral CQ. Recommendations for teacher-educators involve implementing cultural intelligence training into certification programs, establishing a diverse learning environment for teachers, participating in cross-cultural professional experiences, redesigning programs that address gaps in cognitive cultural knowledge while supporting novice teachers' motivation.

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