



CROSS-CULTURAL COMPETENCE AND SKILLS IN HIGHER EDUCATION: A GENERALIZED LINEAR MODELING APPROACH TOWARDS A CULTURE-BASED EXTENSION PROGRAM

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Abstract

Despite increasing emphasis on crosscultural competence and 21stcentury skills in higher education, most of the studies have relied on descriptive or correlational methods, limiting predictive insights. This study addressed that gap by developing a Generalized Linear Model (GLM) to explain how 21stcentury skills influence crosscultural competence among students, serving as the basis for a culturebased extension program. Data from 319 respondents were analyzed using descriptive statistics and GLM. Findings revealed moderate levels of both crosscultural competence and 21stcentury skills, suggesting that while foundational abilities exist, they remain underdeveloped. Communication and collaboration emerged as the strongest predictors of crosscultural competence, underscoring the importance of interactiondriven skills. The Gamma loglink model provided the best fit, confirming that the relationship is nonlinear, contextdependent, and shaped by uneven learning experiences. The study concludes that crosscultural competence is a multidimensional construct shaped by cognitive, behavioral, and affective domains, and strengthened through interaction, experience, and reflection. Anchored in constructivist and intercultural competence theories, the results highlight the need for experiential, collaborative, and culturally responsive learning environments. These findings provide empirical support for a culturebased extension program designed to enhance students' readiness for global and multicultural engagement.

Keywords: cross-cultural skills, competency skills, higher education, generalized linear modeling, extension program

Introduction

The Philippine higher education sector has consistently identified both cross-cultural competence and 21st-century skills as being central to globalization, internationalization, and digital transformation. Therefore, it was effective in assisting learners to adapt to diverse and increasingly knowledge-based environments (Pacione, 2011; Hattie, 2009; Johnson & Johnson, 2009; Robinson, 2011) c[Reviewer1.1]ross-cultural competence emphasizes cultural awareness, openness and a recognition of cultural difference as necessary for meaningful interactions between different cultures in a multicultural learning environment within higher education (Deardorff, 2006; Chen & Starosta, 2000). Furthermore, the majority of higher education students have been shown to have moderately high levels of intercultural sensitivity, particularly in relation to interacting with people from other cultures and demonstrating respect towards their culture; this suggests that through formal education and experience gained whilst engaging in multiculturalism, these competencies can be developed.

Recent studies highlighted the integration of culturebased and inclusive pedagogies in alignment with global education agendas such as Sustainable Development Goal 4,

which advocated equitable, culturally responsive, and quality education (GonzálezPérez & RamírezMontoya, 2022; UNESCO, 2017). Higher education institutions increasingly adopted flexible, technologymediated, and globally oriented learning environments, where digital literacy and global connectivity expanded opportunities for intercultural engagement and collaborative learning (Greenhow & Lewin, 2016). Within this context, crosscultural competence was conceptualized as a multidimensional construct comprising cognitive (knowledge), behavioral (skills), and affective (attitudes) components, shaped by instructional practices and learners' sociocultural experiences (Chen & Hu, 2023; Deardorff, 2006).

Despite these advances, notable gaps persisted. Existing studies predominantly employed descriptive and correlational methods, which limited analytical insight into the dynamic interactions between crosscultural competence and 21stcentury skills. Although students often reported high competency levels, enduring challenges, including limited selfawareness, insufficient skillbased education, career uncertainty, and cultural disconnectedness, continued to impede development. Institutional barriers such as weak policies, fragmented program integration, and inadequate monitoring further constrained the operationalization of culturebased education (Baron, 2023; Pelayo et al., 2025). Theoretically, few studies modeled predictive relationships among competence variables, resulting in fragmented understandings of their impact on educational outcomes. Practically, the absence of statistical modeling restricted the design of sustainable, evidencebased extension programs. These limitations underscored the need for analytical approaches that moved beyond description toward explanation and prediction.

Addressing these gaps, the present study examined crosscultural competence and 21stcentury skills among higher education students using a Generalized Linear Modeling (GLM). Specifically, it analyzed the predictive relationships among the 4Cs and dimensions of crosscultural competence, while considering contextual challenges (e.g., selfawareness deficits, skill gaps, cultural disconnectedness) and opportunities (e.g., digital literacy, global connectivity). Methodologically, GLM provided a statistical approach to test theoretical assumptions, model variable interactions, and generate predictive insights from a commonly utilized correlation analysis. The study ultimately sought to inform the development of empirically grounded, culturebased extension programs. This research contributed both theoretically and practically. Theoretically, it advanced the literature by integrating crosscultural competence and 21stcentury skills within a predictive modeling framework, addressing the lack of advanced statistical analyses in prior work. Unlike studies that primarily described competency levels (Pelayo et al., 2026), this study provided a nuanced account of how competencies interacted and influenced one another. Practically, it supported the design of datadriven, culturebased enhancement programs tailored to higher education institutions. By bridging the gap between assessment and program design, the study responded to the urgent need for structured, evidencebased interventions that fostered culturally responsive, inclusive, and skilloriented education. In doing so, it strengthened crosscultural competence frameworks and advanced educational practice in contemporary higher education.

Research Problem

Higher education increasingly emphasizes cross-cultural competence and 21st-century skills, yet their interaction and influence on student outcomes remain poorly understood. Evidence suggests students demonstrate only moderate proficiency in both domains, underscoring a gap between foundational knowledge and advanced application. Existing studies, largely descriptive and correlational, provide limited insight into predictive relationships, resulting in a fragmented understanding of how the 4Cs collectively shape cross-cultural competence within specific institutional contexts. Moreover, constraints such as limited experiential

learning, uneven instructional practices, and inadequate institutional support hinder students' engagement and confidence in intercultural settings. The absence of predictive, data-driven models further restricts the design of targeted interventions. To address these gaps, advanced analytical approaches, particularly Generalized Linear Modeling, are needed to clarify these relationships and establish an empirical foundation for a culture-based enhancement program.

Research Focus

This study described the pedagogical approaches in higher education and determined its relationship to student competencies, with particular attention to cross-cultural competence and the 21st-century skills of critical thinking, communication, collaboration, and creativity. It examined how these competencies are manifested, how variations influence student development, and where gaps emerge between perceived competence and actual skill integration. Challenges in practical application within institutional contexts were also identified. To move beyond descriptive accounts, the study employed Generalized Linear Modeling to generate predictive, empirical evidence that can inform the design of a culture-based enhancement program, strengthen competency-based instruction, and ultimately improve student outcomes in higher education.

Research Aim

This study intended to generate a Generalized Linear Model that best illustrates the relationship between cross-cultural competence and 21st-century competency skills among higher education students as a basis for a culture-based enhancement program. Specifically, it sought to answer the following questions:

1. What was the perceived assessment of the respondents on cross-cultural competence in terms of the following dimensions:
 - 1.1 interaction engagement;
 - 1.2 respect for cultural differences;
 - 1.3 interaction confidence; and,
 - 1.4 interaction attentiveness?
2. What was the perceived assessment of the respondents on 21st-century competency skills in terms of the following domains:
 - 2.1 critical thinking;
 - 2.2 communication;
 - 2.3 collaboration; and,
 - 2.4 creativity?
3. Which among the significant factors of cross-cultural competence affect the 21st-century competency skills of higher education students?
4. What Generalized Linear Model best fits to illustrate the relationship between cross-cultural competence and 21st-century competency skills among higher education students?
5. What culture-based extension program may be proposed based on the results of the study?

Research Methodology

Design

This study used a quantitative descriptive-correlational design to assess and describe the relationship between cross-cultural competence and 21st-century skills among higher education students. Descriptive statistics, such as weighted mean and standard deviation, were used to determine the students' levels of competence in intercultural dimensions, including interaction engagement, respect for cultural differences, interaction confidence, and attentiveness, as well as in the 21st-century skill areas of critical thinking, communication, collaboration, and creativity.

To ascertain the relationship between these variables, Generalized Linear Modeling (GLM) was applied. This allowed the study to determine the predictive relationships and handle data with non-normal distributions (Creswell, 2018). Different model specifications, such as Gaussian and Gamma log link models, were compared using goodness-of-fit measures including AIC, BIC, and deviance to determine the most appropriate model. Data were collected through a structured Likert-scale survey, which provided a reliable basis for analyzing how 21st-century skills influence cross-cultural competence. By combining descriptive analysis and predictive modeling, the study developed an evidence-based community extension program that may support the creation of a culture-based enhancement program (Hero, 2026).

Sample

This study used simple random sampling to give students from different academic programs and year levels an equal chance of being selected, helping reduce selection bias and improve the representativeness of the participants (Creswell, 2018). The research population consisted of 1850 undergraduate students enrolled in all the offered programs in one state university in Sultan Kudarat during the conduct of the study. The respondents came from different academic programs and from first- to fourth-year levels, ensuring that the sample reflected the diversity of the student population within the institution. A total of 319 undergraduate students participated in the study. The sample size was calculated using Yamane's (1967) formula, a widely accepted method for determining an appropriate sample size in survey research. Using a 5% margin of error, the formula ensured that the number of respondents was sufficient to produce reliable data and support valid statistical conclusions.

After identifying the required sample size, proportional allocation was applied to determine how many respondents would come from each academic program and year level. The participants were then selected through simple random sampling within each group. This procedure ensured that all students had an equal opportunity to participate while maintaining fair representation of the university population. The respondents were officially enrolled students with adequate exposure to academic and intercultural learning experiences. This enabled the study to provide meaningful responses to the study variables. The combination of simple random sampling and proportional allocation strengthened the credibility, reliability, and representativeness of the findings. These procedures helped ensure that the results accurately reflected the experiences of the student population within the university and provided a sound basis for making valid conclusions aligned with the study's quantitative research design (Creswell, 2018).

Instrument and Procedures

The study utilized a self-administered survey questionnaire to measure crosscultural competence and 21stcentury skills among students in a state university in Sultan Kudarat.

The instrument was developed from an extensive review of related literature and anchored on established frameworks of intercultural competence and 21st-century skills, following a structured quantitative survey design. It consisted of two parts: the first assessed cross-cultural competence across four dimensions, such as interaction engagement, respect for cultural differences, interaction confidence, and interaction attentiveness. While the second measured 21st-century skills based on the “4Cs”: critical thinking, communication, collaboration, and creativity. All items were rated on a 5-point Likert scale (5 = Strongly Agree to 1 = Strongly Disagree), allowing respondents to indicate their level of agreement with each statement.

To ensure validity, the instrument underwent expert review by specialists in education, research, and intercultural studies, focusing on content and face validity. Revisions were made to improve clarity and alignment with the study constructs. Reliability was established through a pilot test with respondents outside the target population, and internal consistency was confirmed using Cronbach’s alpha, which yielded acceptable coefficients ($\alpha \geq 0.7$) (Taber, 2018). Specifically, cross-cultural competence items achieved $\alpha = 0.85$, while 21st-century skills items achieved $\alpha = 0.89$. These results indicated strong reliability, affirming the instrument’s suitability for data collection and for generating inputs to the Generalized Linear Modeling analysis.

Data Analysis

The data gathered from the survey were analyzed using appropriate descriptive and inferential statistical techniques. Statistical analysis was performed using software such as JAMOWI to ensure accuracy, efficiency, and reproducibility of results. Descriptive statistics, including weighted mean and standard deviation, were used to determine the level of cross-cultural competence and 21st-century competency skills among the respondents. These measures provided a summary of central tendency and variability, allowing the study to establish the overall patterns and distribution of responses across the identified dimensions. Prior to inferential analysis, the Shapiro–Wilk test was conducted to assess the normality of the data. This step determined whether the data met the assumptions of normal distribution and guided the selection of appropriate statistical models. Given that perception-based data, it exhibited a non-normal distribution, this justified the use of more flexible analytical approaches such as Generalized Linear Modeling (GLM).

To examine the relationships between variables, bivariate correlation analysis was initially conducted to identify significant associations between 21st-century competency skills and cross-cultural competence. This provided a preliminary understanding of the direction and strength of relationships among the variables. Building on this, Generalized Linear Modeling (GLM) was employed as the primary inferential technique to determine the predictive influence of 21st-century competency skills (critical thinking, communication, collaboration, and creativity) on cross-cultural competence. Both Gaussian and Gamma log-link models were tested to compare alternative distributional assumptions and identify the most appropriate model for the data. Model fit was evaluated using statistical indices such as Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), deviance, and log-likelihood, where lower values indicated better model fit. The selection of the best-fitting model was based on goodness-of-fit results and theoretical alignment, ensuring that the chosen model accurately represented the structure of the data and the nature of the variables. This analytical approach allowed the study to move beyond simple association and establish a predictive model that explains how 21st-century competency skills influence cross-cultural competence.

Ethical Considerations

The study adhered to established ethical standards for research involving human participants. Institutional approval was obtained before data collection, and respondents were fully informed of the study’s purpose, scope, and procedures. Informed consent ensured voluntary participation and the right to withdraw at any time. Compliance with the Data Privacy Act of 2012 (Republic Act No. 10173) was observed by safeguarding personal information, maintaining anonymity, and treating all data with strict confidentiality. Care was taken to avoid physical, psychological, or emotional harm, with survey items designed to be nonintrusive and free from coercion or deception. Ethical principles of respect, beneficence, and justice guided the process. The researcher also acknowledged the responsible use of AI tools (e.g., ChatGPT) for language refinement and organization, limited to improving clarity without replacing critical analysis or interpretation. All AI-assisted outputs were reviewed for accuracy and originality, sources were properly cited, and data were securely stored with plans for appropriate disposal after study completion.

Research Results

Cross-cultural competence has become an essential skill in higher education, particularly in increasingly diverse and multicultural learning environments. Understanding how students perceive and respond to cultural differences is important in determining their readiness to engage effectively with individuals from various cultural backgrounds. In this study, cross-cultural competence was examined through the dimensions of interaction engagement, respect for cultural differences, interaction confidence, and interaction attentiveness. The results are presented in Table 1.

Table 1
Descriptive Analysis of the Cross-Cultural Competence of University Students

Indicators	$\bar{X}_w$	σ	CV	η^2	Interpretation
Interaction Engagement	3.41	0.89	0.21	0.00	Moderate
Respect for Cultural Differences	3.32	0.66	0.18	0.00	Moderate
Interaction Confidence	3.49	0.87	0.20	0.01	Moderate
Interaction Attentiveness	3.53	0.76	0.22	0.00	High
Average	3.44	0.76	0.19		Moderate

The descriptive analysis presented in Table 1 analyzed the cross-cultural competence of university students in terms of interaction engagement, respect for cultural differences, interaction confidence, and interaction attentiveness. The aim of this analysis was to determine how students perceive and respond to cultural diversity within their academic and social interactions.

As shown in Table 1, the respondents demonstrated a moderate level of cross-cultural competence, reflected in the overall mean score of 3.44 with a standard deviation of 0.76. The coefficient of variation, which is equal to 0.19, indicates that the responses were relatively consistent across participants, suggesting that students shared similar perceptions and experiences regarding intercultural interaction. Among the four dimensions, interaction attentiveness obtained the highest mean score, interpreted as high. On the other hand, interaction engagement, respect for cultural differences, and interaction confidence were all interpreted as moderate.

The findings suggest that students are generally aware of and sensitive to cultural differences, particularly in terms of being attentive and respectful during intercultural interactions. Many of the respondents appear to be careful and observant when communicating with people from different cultural backgrounds. However, the moderate ratings in engagement and confidence indicate that students may still feel hesitant or uncertain when actively participating in intercultural exchanges. While they show openness toward diversity, they may not yet feel fully comfortable expressing themselves or interacting confidently in multicultural settings. The low coefficients of variation across all indicators further suggest that cross-cultural competence is a commonly shared characteristic among the respondents. At the same time, the results of the Shapiro–Wilk test revealed that the data were not normally distributed, implying that students’ experiences and levels of intercultural exposure may differ depending on their background, social interaction, and learning environment.

The findings support the idea that cross-cultural competence develops through experience, interaction, and exposure to diverse environments. The results also suggest that awareness alone is not enough to strengthen intercultural competence. Students need more opportunities to engage in meaningful cultural interactions that can help build their confidence, communication skills, and active participation in multicultural settings. These findings provide support for the development of culture-based educational interventions and extension programs that promote experiential learning, collaboration, and intercultural engagement.

In today’s rapidly changing and globally connected society, 21st-century competency skills play an important role in preparing students for academic, professional, and intercultural engagement. Skills such as critical thinking, communication, collaboration, and creativity are considered essential in helping learners adapt to complex and diverse environments. In this study, the level of students’ 21st-century competency skills was examined across these four domains, and the results are presented in Table 2.

Table 2
Descriptive Analysis of the 21st-Century Competency Skills of University Students

Indicators	$\bar{X}_w$	S	CV	η^2	Interpretation
Critical Thinking	3.63	0.74	0.20	0.00	Moderate
Communication	3.70	0.66	0.18	0.00	Moderate
Collaboration	3.54	0.69	0.19	0.00	Moderate
Creativity	3.57	0.70	0.20	0.00	Moderate
Average	3.61	0.70	0.20		High

The descriptive analysis presented in Table 2 described and analyzed the 21st-century competency skills of university students in terms of critical thinking, communication, collaboration, and creativity. This analysis aimed to determine the extent to which students possess the competencies needed to function effectively in academic, professional, and culturally diverse environments.

As shown in Table 2, the respondents demonstrated a generally favorable level of 21st-century competency skills, with an overall mean score of 3.61 and a standard deviation of 0.70, interpreted as high. The coefficient of variation, which is equal to 0.20, indicates relatively low variability in responses, suggesting that students shared similar perceptions regarding their competency skills across the different domains assessed. Among the indicators, communication obtained the highest mean score, followed by critical thinking, creativity, and collaboration. Although the overall results were favorable, all indicators were interpreted as moderate.

The findings suggest that students already possess the basic competencies expected in 21st-century learning, particularly in expressing ideas and communicating effectively with others. The high rating in communication may indicate that students are generally comfortable sharing ideas, participating in discussions, and engaging in academic interactions. However, the lower rating in collaboration suggests that students may still encounter difficulties in teamwork, shared decision-making, and collective problem-solving. Similarly, the moderate ratings in critical thinking and creativity imply that while students demonstrate these skills to some extent, there is still a need to strengthen their ability to apply them in more complex, real-life, and interdisciplinary situations.

The consistently low coefficients of variation across all domains further indicate that these competencies are commonly experienced among the respondents, possibly reflecting similarities in their academic exposure and learning experiences. Nevertheless, the moderate ratings across the indicators point to areas that still require improvement, particularly in promoting deeper critical inquiry, innovative thinking, and collaborative engagement. In addition, the results of the Shapiro–Wilk test revealed that the data were not normally distributed, suggesting that students' competency levels may vary depending on their learning experiences, exposure to diverse environments, and individual participation in academic and social activities. This finding also supports the use of flexible inferential techniques such as Generalized Linear Modeling in the succeeding analyses.

The findings suggest that students possess emerging 21st-century competency skills, although these competencies are still developing and may not yet be fully applied in more demanding or real-world contexts. The results highlight the importance of providing students with more meaningful and experience-based learning opportunities that encourage critical thinking, creativity, collaboration, and effective communication. The findings also support the view that 21st-century skills are dynamic and continuously shaped by instructional practices, social interaction, and experiential learning. Hence, the results provide support for the development of culture-based educational interventions and enhancement programs that integrate collaborative learning, authentic problem-solving activities, and interdisciplinary engagement to strengthen students' competencies in a globalized and culturally diverse society.

Generalized Linear Model Using Gaussian Log-Link in Examining the Relationship between 21st-Century Competency Skills and Cross-Cultural Competence

A Generalized Linear Model (GLM) using the Gaussian distribution with a log-link function was employed to examine the relationship between 21st-century competency skills and cross-cultural competence. This approach was utilized to determine which competency skills significantly predict students' cross-cultural competence across diverse cultural contexts.

Table 3
Parameter Estimates (Coefficients)

Name	Estimate	SE	95% Confidence Intervals		z	p
			Lower	Upper		
(Intercept)	1.002	0.009	1.121	1.142	153.600	< .001
Interaction Engagement	0.073	0.014	0.043	0.079	6.880	< .001*
Respect for Cultural Differences	0.078	0.010	0.040	0.089	6.553	< .001*
Interaction Confidence	0.091	0.009	0.058	0.109	8.280	< .001*
Interaction Attentiveness	0.02	0.006	-0.000	0.043	2.869	.080

The results of the Generalized Linear Model (GLM) using the Gaussian log-link revealed that the different dimensions of cross-cultural competence were associated with students' 21st-century skills in varying ways. The findings showed that students who demonstrated stronger intercultural engagement, greater respect for cultural differences, and higher confidence in intercultural interactions also tended to exhibit stronger 21st-century competencies. These results suggest that students who are more comfortable interacting with individuals from diverse cultural backgrounds are more likely to communicate effectively, collaborate with others, and apply critical thinking in different learning situations.

Among the identified dimensions, interaction confidence emerged as the strongest predictor of 21st-century skills. This finding highlights the importance of self-assurance and comfort in intercultural communication, suggesting that students who feel more confident in engaging with culturally diverse individuals are also more capable of participating actively in collaborative and intellectually demanding environments. Likewise, interaction engagement and respect for cultural differences also showed meaningful contributions, indicating that openness to diversity and active participation in intercultural experiences play an important role in strengthening students' competencies needed in contemporary education and society.

In contrast, interaction attentiveness did not demonstrate a statistically significant influence on students' 21st-century skills. Although students may be attentive and aware during intercultural interactions, the findings suggest that attentiveness alone may not be sufficient to strengthen competencies such as communication, collaboration, and critical thinking. This implies that awareness of cultural differences becomes more meaningful when accompanied by active participation, interaction, and shared learning experiences.

The findings support constructivist perspectives, which emphasize that learning develops through communication, interaction, and social engagement. The results further suggest that cross-cultural competence and 21st-century skills are closely interconnected, particularly through interaction-driven experiences that encourage participation, confidence, and collaboration. Overall, the model highlights the importance of creating culturally responsive and collaborative learning environments where students are encouraged not only to recognize diversity but also to actively engage, communicate, and work with individuals from different cultural backgrounds.

Table 4
Model Fit of Gaussian Log Link Model

R^2	df	χ^2	p
0.788	4	139.781	<.001

To determine whether the Gaussian log-link model adequately explained the relationship between 21st-century skills and cross-cultural competence, several model fit indices were examined. The results presented in Table 4 show that the model provided a strong and statistically significant explanation of the relationship between the variables.

The findings indicate that the combined influence of critical thinking, communication, collaboration, and creativity substantially explained variations in students' cross-cultural competence. This suggests that 21st-century competency skills play an important role in shaping how students interact, communicate, and function within culturally diverse environments. The strong explanatory power of the model further implies that these competencies are closely interconnected and contribute meaningfully to students' intercultural development.

The results also confirmed that the model was statistically significant, indicating that the relationship between 21st-century skills and cross-cultural competence was not due to

chance. This means that students who demonstrate stronger communication, collaboration, creativity, and critical thinking skills are also more likely to exhibit higher levels of intercultural competence. The findings reinforce the idea that skill-based learning is essential in preparing students to engage effectively in multicultural and global contexts. Moreover, the strong model fit supports contemporary educational perspectives that emphasize communication, collaboration, and critical thinking as key competencies for intercultural engagement. The findings suggest that these skills should be more intentionally integrated into higher education curricula through experiential, collaborative, and culturally responsive learning opportunities. By doing so, educational institutions can better prepare students to become confident, adaptive, and globally competent individuals capable of thriving in culturally diverse academic and professional environments.

In sum, the results provide empirical support for the development of culture-based enhancement programs that combine competency development with meaningful intercultural learning experiences.

Table 5
Additional Indices of Gaussian Log Link Model

Info	Model Value	Comment
Log Likelihood	-222.390	
AIC	472.143	Less is better
BIC	487.645	Less is better
Deviance	75.821	Less is better
Residual DF	362	
Chi-squared/DF	0.189	Overdispersion indicator

To further assess the adequacy of the Gaussian log-link model, additional goodness-of-fit indices were examined. These indices provided a deeper evaluation of how well the model explained the relationship between 21st-century skills and cross-cultural competence. The results are presented in Table 5.

The findings suggest that the Gaussian log-link model demonstrated an acceptable level of fit in explaining the relationship between the variables. The model was able to account for a substantial portion of the variability in cross-cultural competence, indicating that 21st-century skills contribute meaningfully to students' intercultural development. At the same time, the results also imply that some aspects of cross-cultural competence remain unexplained by the variables included in the model. This suggests that other factors beyond critical thinking, communication, collaboration, and creativity may also influence how students develop intercultural competence. The additional fit indices further indicate that the model satisfied important statistical assumptions and showed no evidence of overdispersion, suggesting that the variability in the data was adequately handled by the model. However, the overall fit statistics also point to the possibility that alternative models may provide a stronger explanation of the relationship between the variables. This implies that while 21st-century skills are important predictors of cross-cultural competence, they may not fully capture the complexity of students' intercultural experiences and development.

Theoretically, the findings reinforce the idea that cross-cultural competence is a multidimensional construct shaped not only by individual skills but also by broader contextual and experiential factors. Students' intercultural competence may also be influenced by their cultural exposure, institutional environment, social interaction, and participation in diverse learning experiences. These factors may help explain why some aspects of intercultural

competence are not fully accounted for by the current model. The additional goodness-of-fit indices suggest the need to further refine and strengthen the model by incorporating wider educational and contextual variables in future analyses. This provides a more comprehensive understanding of how cross-cultural competence develops among higher education students and may also contribute to the design of more responsive culture-based educational interventions and enhancement programs.

Generalized Linear Model Using Gamma Log-Link in Examining the Relationship between 21st-Century Competency Skills and Cross-Cultural Competence

A Generalized Linear Model (GLM) using the Gamma distribution with a log-link function was employed to examine the relationship between 21st-century competency skills and cross-cultural competence. This approach was used due to the non-normal distribution of the data and to determine which competency skills significantly influence students' cross-cultural competence in diverse cultural settings.

Table 6
Parameter Estimates (Coefficients)

Name	Estimate	SE	95% Confidence Intervals		z	p
			Lower	Upper		
(Intercept)	1.122	0.006	1.108	1.129	159.119	< .001*
Interaction Engagement	0.065	0.013	0.040	0.079	5.985	< .001*
Respect for Cultural Differences	0.073	0.012	0.054	0.091	6.639	< .001*
Interaction Confidence	0.115	0.013	0.089	0.128	10.527	< .001*
Interaction Attentiveness	0.019	0.007	0.006	0.040	2.447	.011*

The results of the Generalized Linear Model (GLM) using the Gamma log-link showed that the dimensions of cross-cultural competence significantly influenced students' 21st-century skills. Specifically, interaction engagement, respect for cultural differences, interaction confidence, and interaction attentiveness all demonstrated positive and statistically significant relationships with students' competencies in critical thinking, communication, collaboration, and creativity. This means that students who were more open, confident, respectful, and attentive in intercultural situations also tended to demonstrate stronger 21st-century skills.

Among the identified dimensions, interaction confidence emerged as the strongest predictor of students' 21st-century skills. This finding suggests that students who feel more comfortable and confident interacting with individuals from different cultural backgrounds are more likely to communicate effectively, collaborate with others, and think critically in diverse learning environments. Interaction engagement and respect for cultural differences also demonstrated meaningful contributions, indicating that openness to diversity and active participation in intercultural experiences help strengthen students' adaptability, communication, and collaborative abilities. Likewise, interaction attentiveness showed a significant influence, suggesting that students who are mindful and observant during intercultural interactions tend to become more responsive and open-minded in group discussions, teamwork, and problem-solving activities.

The results highlight how cross-cultural competence and 21st-century skills develop together. Intercultural experiences not only help students become culturally aware; they also strengthen important life and learning skills needed in today's global and interconnected

environment. This supports the idea that meaningful learning happens through interaction, collaboration, and exposure to diverse perspectives.

The Gamma log-link model also provided a better fit than the Gaussian model because it was more appropriate for the non-normal and uneven nature of perception-based data. This suggests that the development of cross-cultural competence and 21st-century skills does not happen in a fixed or uniform way but is shaped by students' varied experiences, interactions, and learning environments. Overall, the findings emphasize the importance of creating learning spaces that encourage intercultural interaction, collaboration, and experiential learning to help students become more globally competent and adaptable individuals.

Table 7
Model Fit Gamma Log Link Model

<i>R</i> ²	<i>df</i>	χ^2	<i>p</i>
0.678	4	13.668	<.001

The model fit results presented in Table 7 indicate that the Gamma log-link model provided a strong and statistically significant explanation of the relationship between 21st-century skills and cross-cultural competence. The findings show that the combined influence of critical thinking, communication, collaboration, and creativity meaningfully explained variations in students' cross-cultural competence, suggesting that these competencies play an important role in shaping students' ability to interact effectively in culturally diverse environments.

The results further confirmed that the model was statistically significant, indicating that the relationship between 21st-century skills and cross-cultural competence was not due to chance. This suggests that students who demonstrate stronger communication, collaboration, creativity, and critical thinking skills are also more likely to exhibit higher levels of intercultural competence. The findings reinforce the idea that 21st-century competencies contribute substantially to students' readiness to function in multicultural academic and social contexts.

These findings indicate that all four competency domains collectively contribute to explaining intercultural competence, reinforcing their complementary and interactive influence. Compared to the Gaussian model, the Gamma loglink model demonstrates a more appropriate fit, capturing relationships more effectively under conditions that account for nonnormal and uneven data distributions. From a theoretical perspective, the results support 21stcentury learning frameworks and constructivist principles, which emphasize that communication, collaboration, and critical thinking are central to effective intercultural engagement. The strong model fit confirms that these competencies are not only conceptually relevant but also empirically significant predictors of crosscultural competence, while creativity adds adaptability and openness in diverse cultural settings. The Gamma loglink model provides a robust and statistically adequate explanation of how 21stcentury skills shape crosscultural competence. These findings strengthen the conclusion that enhancing these competencies is essential for preparing students to thrive in multicultural and globalized environments, offering empirical support for the development of a culturebased enhancement program that integrates skill development with experiential intercultural learning.

Table 8
Additional Indices of the Gamma Log-Link Model

Info	Model Value	Comment
Log Likelihood	-197.165	
AIC	410.345	Less is better
BIC	430.035	Less is better
Deviance	6.658	Less is better
Residual DF	368	
Chi-squared/DF	0.021	Overdispersion indicator

Table 10 presents the goodness-of-fit indices for the Generalized Linear Model using the Gamma log-link in examining the relationship between 21st-century competency skills and cross-cultural competence. The results indicate that the model adequately explained the observed data and maintained a good balance between explanatory power and model simplicity. The findings further suggest that only a small portion of the variation in cross-cultural competence remained unexplained by the predictors included in the model. This implies that the variables related to 21st-century skills contributed meaningfully to explaining differences in students' intercultural competence. In addition, the results showed no evidence of overdispersion, indicating that the assumptions of the Gamma model were adequately satisfied and that the model was appropriate for the nature of the dataset.

Compared with the Gaussian model, the Gamma log-link model demonstrated better goodness-of-fit results, suggesting that it was more suitable for handling the non-normal and perception-based nature of the data. This indicates that the Gamma model was able to capture the variability in students' responses more effectively and provide a more accurate explanation of the relationship between the variables. The findings also highlight the important role of 21st-century competency skills in shaping students' cross-cultural competence. Students who demonstrate stronger communication, collaboration, creativity, and critical thinking skills also tend to exhibit better intercultural understanding and interaction. These results support the idea that the development of 21st-century skills is closely connected to students' readiness to participate effectively in culturally diverse and global environments.

Overall, the results reinforce the value of experiential, collaborative, and culturally responsive learning opportunities in strengthening both students' competency skills and intercultural capabilities.

Table 9

Linear Model that Best Fits to Illustrate the Relationship between 21st-Century Competency Skills and Cross-Cultural Competence

Generalized Linear Model Using Gaussian Log-Link		
Info	Model Value	Comment
Log Likelihood	-222.390	
AIC	472.143	Less is better
BIC	487.645	Less is better
Deviance	75.821	Less is better
Residual DF	362	
Chi-squared/DF	0.189	Overdispersion indicator

Generalized Linear Model Using Gamma Log-Link		
Info	Model Value	Comment
Log Likelihood	-197.165	
AIC	410.345	Less is better
BIC	430.035	Less is better
Deviance	6.658	Less is better
Residual DF	368	
Chi-squared/DF	0.021	Overdispersion indicator

Table 9 presents the comparison between the Gaussian and Gamma log link models in explaining the relationship between 21st-century skills and cross-cultural competence. The results show that the Gamma model provided a better fit for the data across all statistical indicators. It obtained a higher log likelihood value (-197.165) compared to the Gaussian model (-222.390), indicating stronger explanatory power. In addition, the Gamma model produced lower AIC and BIC values, suggesting that it represented the data more accurately and efficiently. The deviance value of the Gamma model (6.658) was also much lower than that of the Gaussian model (75.821), meaning that less variation in the data remained unexplained.

The Gamma model consistently showed better fit across all goodness-of-fit indices. It produced lower AIC, BIC, and deviance values, along with a higher log-likelihood value, indicating that it represented the data more accurately and with less unexplained variation. While the Gaussian model explained a larger proportion of variance, its higher R^2 may have been influenced by its assumption of normality, which was inconsistent with the actual distribution of the data. In contrast, the Gamma model was more appropriate for handling skewed and perception-based data, making it statistically and theoretically more suitable for the study.

The stronger performance of the Gamma model may be explained by the nature of cross-cultural competence and 21st-century skills, which are influenced by varied learning experiences, social interactions, and educational contexts. These competencies do not always develop in a uniform or predictable manner. As noted in recent studies, skills such as communication, collaboration, and critical thinking often develop differently depending on students' exposure and learning opportunities. Because of this, the data may not follow a perfectly normal distribution, making the Gamma model more suitable than the Gaussian model. Hence, the findings suggest that the Gamma log link GLM better explains the relationship between 21st-century skills and cross-cultural competence. This supports the idea that competency development in higher education is shaped by multiple factors and learning experiences. The results also provide a

stronger basis for developing a culture-based enhancement program that promotes experiential learning and prepares students to interact effectively in diverse cultural settings.

Discussion

The findings of this study revealed that university students demonstrated moderate levels of crosscultural competence and 21stcentury skills, with communication and collaboration emerging as the strongest predictors of intercultural sensitivity. These results align with Deardorff's (2006) conceptualization of intercultural competence as a multidimensional construct shaped by knowledge, skills, and attitudes, and confirm that interactiondriven skills are central to competence development. The predictive strength of communication and collaboration resonates with Johnson and Johnson's (2009) work on cooperative learning, which emphasized that meaningful interaction fosters both cognitive and affective growth in diverse settings. Similar to Chen and Starosta's (2000) findings on intercultural sensitivity, this study observed that students were attentive and respectful of cultural differences but less confident in active engagement. This suggests that while awareness is present, confidence and participation remain underdeveloped. The gap between awareness and application echoes Pelayo et al. (2025), who noted that limited experiential learning opportunities and fragmented institutional support hinder students' ability to translate competence into practice. Our results extend this by showing that confidence in intercultural interaction is not only a personal trait but also a significant predictor of broader 21stcentury skills, particularly collaboration and communication.

The perceived moderate level in creativity and collaboration also parallels Greenhow and Lewin's (2016) observations that digital literacy and global connectivity expand opportunities for intercultural engagement but do not automatically translate into advanced collaborative skills. In fact, the lowest scores in collaboration highlight enduring challenges in teamwork and collective problemsolving, consistent with Baron (2023), who identified institutional barriers such as weak policies and inadequate monitoring as constraints on culturebased education. This suggests that while digital tools provide access to diverse perspectives, structured pedagogical interventions remain necessary to cultivate deeper collaborative competence.

The predictive modeling results further support constructivist perspectives, which argue that learning develops through interaction, communication, and shared experiences (Hattie, 2009). The significant role of interaction confidence in predicting 21stcentury skills underscores the importance of experiential and reflective learning environments. Unlike prior descriptive studies (Pelayo et al., 2026), this study provides empirical evidence that confidence in intercultural exchanges directly strengthens critical thinking, communication, and collaboration. This finding confirms GonzálezPérez and RamírezMontoya's (2022) call for culturally responsive pedagogies aligned with Sustainable Development Goal 4, which advocates equitable and inclusive education. Interaction attentiveness did not significantly predict 21stcentury skills, despite being rated highly by students. This divergence suggests that attentiveness alone, without active engagement, may not be sufficient to foster competence. Chen and Hu (2023) similarly argued that intercultural competence requires not only awareness but also behavioral enactment and affective investment. Our results extend this by showing that attentiveness must be paired with confidence and collaboration to yield measurable skill development.

Overall, the study confirms that crosscultural competence and 21stcentury skills are interconnected, particularly through interactiondriven dimensions. However, the moderate levels observed highlight the need for intentional, culturebased extension programs that integrate experiential learning, collaborative projects, and reflective practices. By situating these findings within existing literature, this study clarifies that while foundational competencies are

present, their development is uneven and contextdependent. This reinforces the importance of institutional support, structured interventions, and culturally responsive pedagogy in preparing students for global and multicultural engagement.

Limitations of the Study

Despite the significant findings of the study, several limitations should be acknowledged. First, the study was conducted in only one state university, which may limit the generalizability of the results to other higher education institutions with different cultural, academic, and demographic contexts. As such, the findings primarily reflect the experiences and perceptions of students within a specific institutional environment. Another limitation involves the use of self-reported questionnaires as the main source of data. Since the study relied on students' personal perceptions and responses, there is a possibility of social desirability bias, where respondents may have answered in ways they believed were more acceptable or favorable. While the instrument measured perceived levels of cross-cultural competence and 21st-century skills, these responses may not fully represent students' actual behaviors and experiences in real intercultural situations.

The study also employed a purely quantitative design, which limited the depth of interpretation regarding students' lived experiences and personal perspectives. Although the use of Generalized Linear Modeling provided strong statistical insights into the relationships between variables, the design was unable to capture the deeper social and contextual factors that shape intercultural competence development. Qualitative approaches, such as interviews or focus group discussions, could have provided richer explanations of how students experience and navigate cultural interactions. The study used a cross-sectional research design, meaning that data were collected at only one point in time. Because of this, the study could not determine causal relationships or examine how cross-cultural competence and 21st-century skills develop over time. Competency development is often gradual and influenced by continuous experiences, suggesting the need for longitudinal studies that can better track changes and growth among students.

Conclusions and Implications

The study concluded that higher education students demonstrated moderate levels of both cross-cultural competence and 21st-century skills. While foundational abilities were present, these competencies were not yet fully developed. Students showed strong awareness and sensitivity to cultural diversity, particularly in interaction attentiveness, but dimensions such as engagement, respect for differences, and confidence remained at moderate levels. This suggested that awareness had not yet fully translated into active and meaningful intercultural participation. Similarly, the four domains of 21st-century skills were moderately developed, reflecting a developmental stage that required further enhancement for effective real-world application. The findings further revealed that communication and collaboration were the strongest predictors of cross-cultural competence, underscoring the importance of interaction-driven skills in diverse cultural contexts. The Gamma log-link model provided the best fit, indicating that competence development was non-linear, context-dependent, and shaped by uneven learning experiences. Overall, the study affirmed that cross-cultural competence was a multidimensional construct that required not only awareness but also active engagement, interaction, and experiential learning.

The findings of the study carried important implications for higher education, particularly in strengthening cross-cultural competence and 21st-century skills among students. The moderate levels of competence observed in both areas suggested that while students possessed

foundational knowledge and awareness, they still required more meaningful and experiential opportunities to fully develop these abilities. This highlighted the need for educators to move beyond traditional content-based instruction and adopt more collaborative, inquiry-based, and student-centered approaches that actively promote communication, collaboration, critical thinking, and creativity in real-world and intercultural contexts. The results also emphasized the importance of embedding cross-cultural competence and 21st-century skills across curricula, institutional programs, and learning environments rather than limiting them to isolated classroom activities. At the institutional level, universities could strengthen multicultural engagement through intercultural programs, global partnerships, community immersion, and culturally responsive teaching practices. The study likewise demonstrated the value of using advanced analytical approaches, such as Generalized Linear Modeling, in educational research to better understand the complex and context-dependent nature of competency development. The stronger performance of the Gamma log-link model further suggested that learning and competence development were non-linear and shaped by varied experiences, interactions, and institutional support. Overall, the findings reinforced the importance of creating inclusive, experiential, and skill-oriented learning environments that prepared students to become confident, adaptive, and globally competent individuals capable of engaging effectively in culturally diverse settings.

Recommendations

In light of these findings, higher education institutions were encouraged to implement culture-based programs that integrated cross-cultural competence and 21st-century skills through experiential, collaborative, and context-driven strategies. Faculty members were encouraged to adopt student-centered pedagogies such as project-based learning, intercultural dialogue, and collaborative activities to strengthen engagement, communication, and confidence in multicultural settings. Institutions were also encouraged to embed these competencies across curricula and promote inclusive learning environments through multicultural programs, global exchanges, and community immersion initiatives. To support effective implementation, universities were encouraged to invest in faculty development programs that equipped educators with strategies for teaching intercultural competence. Future research was recommended to incorporate additional variables such as intercultural exposure, socio-cultural background, and institutional support to improve the explanatory power of predictive models. Mixed-methods and longitudinal designs were also recommended to capture developmental trajectories more fully. Finally, educational planners and policymakers were encouraged to adopt data-driven approaches, such as Generalized Linear Modeling, in designing and evaluating programs that prepared students for meaningful participation in a globalized and culturally diverse society.

Declaration of Interests

No potential conflict of interest was reported by the author.

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