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The Role of Sociodemographic Parameters in Shaping Epistemological Beliefs among Pre-service Teachers - A Structural Equation Modeling Analysis

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Abstract

Epistemological beliefs (EBs) "individuals' conceptions of knowledge acquisition" profoundly shape teaching practices, yet their development in non-Western contexts remains underexplored. This study investigates how demographic factors (gender, residence, academic maturation, and academic performance) influence talent- versus effort-oriented EBs among pre-service teachers in Pakistan, a context marked by urban-rural divides and gendered educational norms. Using Structural Equation Modeling (SEM), data from 330 pre-service teachers revealed three key findings: urban-rural disparities and gendered socialization critically mediate EBs, with rural participants and males endorsing talent-centric views, while urban residents and females emphasized effort-driven epistemologies; academic maturation (semester level) significantly predicted effort-oriented beliefs, demonstrating the transformative role of pedagogical training; talent and effort exhibited dynamic interdependence, challenging binary EB frameworks and highlighting their coexistence in socioculturally finical contexts. Methodologically, this study contributes a culturally adapted SEM framework, validating Schommer's (1990) theory in South Aisa particularly in Pakistan and addressing critiques of Western-centric models. Practically, the findings advocate for equity-driven reforms in teacher education, such as bridging urban-rural resource gaps and integrating reflective pedagogies to nurture educators who view knowledge as malleable. By centering sociocultural context, this research advances global EB scholarship and offers actionable strategies for fostering equitable, inquiry-based classrooms in underserved regions.

Keywords Epistemological Beliefs, Global South, Sociocultural Determinants, Structural Equation Modeling; Teacher Education, Urban-Rural Disparities

Introduction

Epistemological beliefs (EBs) refer to an individuals' conceptions of knowledge acquisition, validation, and structure play a foundational role in shaping learning behaviors, cognitive practices and professional identities (Ventista & Brown, 2023; Hofer, 2004). For pre-service teachers, these beliefs are particularly consequential, as they influence pedagogical choices, classroom dynamics, and adaptability of diverse learner needs (Kutluca & Mercan, 2022;

Madiha & Alibakhshi, 2020). Central to EB frameworks is the dichotomy between *talent* (viewing knowledge as rooted in innate ability) and *effort* (perceiving knowledge as malleable through persistence), with the latter linked with student-centered, inquiry-driven teaching strategies (Yousefi & Khalkhali, 2020; Yağan & Parlar, 2023). While prior research has established the significance of EBs in Western contexts and East Asia, their development in South Asia settings,

particularly in Pakistan, remains unexplored. This gap is critical given the region's unique socio-educational landscape, marked by urban-rural disparities, gendered expectations, and systematic inequalities in resource distribution, factors likely to shape EBs in ways distinct from Global North paradigms (Shoaib et al., 2021; Alkış Küçükaydın et al., 2024; Liang et al., 2023).

Demographic variables such as gender, academic performance (CGPA), academic maturation (semester level), and area of residence (urban vs. rural) are increasingly recognized as pivotal yet understudied influencers of EB development. For instance, gendered socialization processes often predispose women to adopt effort-oriented EBs, fostering adaptive learning strategies and higher cognitive engagement (Er, 2013; Shoaib et al., 2021), while students with elevated academic performance tend to embrace dynamic, process-focused beliefs about knowledge (Lonka et al., 2021). Similarly, urban environments, characterized by greater access to educational resources and diverse pedagogical exposures, may cultivate more sophisticated EBs compared to rural settings, where traditional, teacher-centered methods often dominate (Tong et al., 2024; Alkış Küçükaydın et al., 2024). However, existing studies predominantly employ linear analyses, overlooking the complex interdependencies between these variables. Structural Equation Modeling (SEM) offers a robust alternative, enabling researchers to disentangle direct and indirect pathways through which sociodemographic collectively shape EBs (e.g., talent and effort) (Guo et al., 2022; Heidarzadi et al., 2022).

The current research study addresses these contextual and methodological gaps by applying SEM to investigate how gender, CGPA, academic maturation (semester levels), and area of residence interact to shape talent- versus effort-oriented EBs among pre-service teachers in Pakistan's leading teacher training institution. The choice of SEM is deliberate: it not only quantifies latent relationships between variables but also models the hierarchical structure of EB development, accounting for cultural and systemic distinctions often marginalized in Western-centric research. By focusing on Pakistan 'a context where urban-rural divides, gendered norms, and inequitable resource' allocation profoundly influence educational trajectories, this study advances a culturally insignificant understanding of EB formation.

The scientific significance of this work lies in its dual contribution. First, it challenges the universality of EB frameworks by highlighting how regional disparities and cultural values modulate belief systems, offering insights for global theory-building. Second, it demonstrates SEM's utility in educational research, providing a methodological blueprint for analyzing multidimensional constructs in heterogeneous populations. Practically, the findings hold immediate relevance for teacher educators and policymakers: identifying demographic-linked EB patterns can inform targeted interventions, such as redesigning curricula to counteract fixed beliefs in rural cohorts or integrating reflective pedagogies for students with lower CGPAs. For researchers, this study emphasizes the need to contextualize EB models, particularly in underserved regions where teacher training programs are pivotal to national development goals. Ultimately, by mapping the demographic bases of EBs, this research equips stakeholders to cultivate adaptable, critically engaged educators capable of transforming classrooms into equitable, inquiry-driven spaces.

Theoretical Perspectives

This study is grounded in Schommer's (1990) multidimensional theory of EBs, which suggests that individuals' conceptions of knowledge exist along a continuum from *naive* (static, authority-driven) to *sophisticated* (dynamic, evidence-based). Central to this framework are the constructs of *talent* (knowledge as innate ability) and *effort* (knowledge as malleable through persistence), which reflect core dimensions of how individuals perceive learning and problem-solving (Letina, 2022; Yousefi & Khalkhali, 2020). Schommer's theory emphasizes that EBs are not fixed; they evolve through educational experiences, contextual interactions, and sociocultural influences a premise critical to understanding the demographic predictors explored in this study.

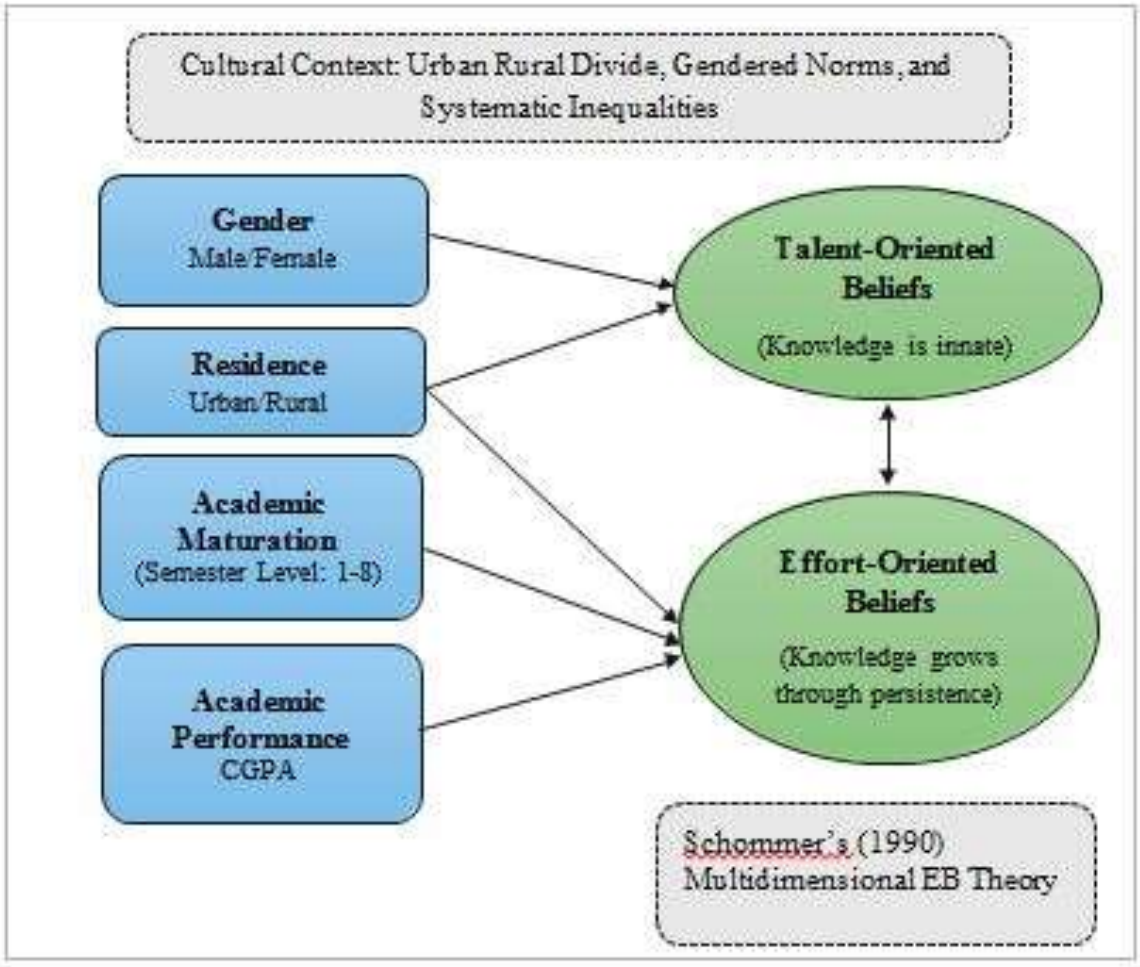
Demographic factors like gender, academic maturation (semester level), academic performance (CGPA), and residential area (urban vs. rural) are theorized to shape EBs by modulating access to resources, socialization processes, and exposure to diverse pedagogical practices (Gholami et al., 2022; Alkış Küçükaydın et al., 2024). For instance, gender-linked socialization often reinforces effort-oriented EBs among women, as cultural norms valorize perseverance in learning (Shoaib et al., 2021; Er, 2013). Conversely, students in advanced semesters or with higher academic performance may develop sophisticated EBs through cumulative academic challenges that highlight knowledge as

a dynamic, effort-driven process (Lonka et al., 2021; Yağan & Parlar, 2023). Similarly, urban-rural disparities in educational infrastructure and pedagogical exposure may entrench talent-oriented beliefs in resource-limited rural settings, where traditional, teacher-centered methods dominate (Tong et al., 2024).

This framework (Figure 1) integrates Schommer's theory with contemporary insights into demographic mediators, proposing that gender, academic maturation (semester level), CGPA, and residence collectively influence the *talent-effort* dichotomy. By conducting this study within Pakistan, a context marked by urban-rural inequities and gendered educational trajectories the study advances a culturally nuanced extension of Schommer's theory, addressing critiques of its Western-centric applicability (Liang et al., 2023).

Figure 1

Theoretical Framework of the Study



Literature Review

Epistemological beliefs (EBs) are pivotal in shaping learning behaviors, pedagogical strategies, and professional identities (Hofer & Pintrich, 1997; Schommer, 1990).

Schommer's multidimensional model positions EBs along a continuum from *naive* (knowledge as fixed, authority-driven) to *sophisticated* (knowledge as dynamic, effort-driven), with *talent* (innate ability) and *effort* (persistence-driven growth) forming core constructs (Yousefi & Khalkhali, 2020; Yağan & Parlar, 2023). Sophisticated EBs correlate with advanced cognitive strategies, academic success, and adaptive teaching practices, particularly among pre-service teachers, who must navigate diverse classroom dynamics (Kutluca & Mercan, 2022; Akkuş et al., 2023). While, western studies dominate EB literature, emerging work highlights sociocultural and demographic mediators' gender, academic progression, residence, and academic performance as critical yet underexplored influencers, particularly in Global South contexts (Liang et al., 2023; Alkış Küçükaydın et al., 2024).

Academic Maturation and EB Development

Academic maturation, as measured by semester-level progression in pre-service teacher education, significantly influences the development of EBs. Advanced semesters expose pre-service teachers to complex pedagogical theories and practical experiences, fostering a shift from dualistic views of knowledge towards more nuanced and contextual understandings (Klopp et al., 2023; Sengul, 2024; Lonka et al., 2021). For example, a pre-service teacher in their first semester view teaching as simply delivering information, while a student in their final semester, having completed student teaching and coursework on differentiated instruction, is more likely to understand the nuances of adapting teaching strategies to meet diverse student needs (Huang & Wang, 2021; Dignath et al., 2021). This transition is supported by longitudinal studies demonstrating that engagement with constructivist frameworks promotes a move away from static, talent-centric perspectives towards dynamic, effort-driven conceptions (Canning et al., 2024; Tong et al., 2024; Biçer & Yıldırım, 2023).

Consider a study where pre-service teachers initially believed that some students are simply "good at learning math" while others are not. After participating in a year-long program emphasizing growth mindset and formative assessment, they began to believe that all students can improve in math with effective teaching and focused effort (Lloyd, 2024). This aligns with the Reflective Judgment Model, where epistemic growth parallels academic maturation, transitioning from authority-dependent truths to contextually negotiated knowledge (King & Kitchener, 2004; Ongowo, 2021). In early stages of epistemic development, a pre-service teacher accepts information from textbooks or professors without question (Heikkilä et al., 2020). However, as they mature academically, they learn to critically evaluate sources, consider different perspectives, and form their own informed judgments based on evidence and reasoning (Ceyhan et al., 2021). Such evolution is critical for educators, as sophisticated EBs enhance pedagogical adaptability and student-centered instruction (Brownlee et al., 2011). For instance, a teacher with well-developed EBs is better equipped to understand and respond to students' misconceptions, adjust their teaching strategies based on student feedback, and create a more inclusive and engaging learning environment. This includes understanding that knowledge is not fixed but evolves with new research and perspectives, allowing them to continuously refine their teaching practices (Keppens et al., 2021). This adaptability is crucial for navigating the complexities of diverse classrooms and promoting equitable learning outcomes for all students (Jaber et al., 2021).

Consequently, the influence of academic maturation on the development of EBs in pre-service teachers warrants further investigation. Specifically, how does semester level or stage of academic preparation impact the sophistication and complexity of epistemological beliefs related to teaching and learning? This exploration is vital for understanding how teacher education programs can best support the development of beliefs that foster effective and equitable teaching practices.

Urban-Rural Disparities in EB Formation

Geographic location, specifically urban versus rural environments, significantly influences the formation of prospective teachers' EBs (Truscott & Obiwo, 2021). Disparities in resource access and pedagogical exposure differentially shape these beliefs, impacting how educators perceive knowledge and its acquisition (Odebiyi & Choi, 2020; Richmond et al., 2024).

Urban teachers, immersed in interdisciplinary collaborations, access to technology, and innovative practices like project-based learning, often adopt effort-oriented, constructivist beliefs, viewing knowledge as socially negotiated (Alkış Küçükaydın et al., 2024; Lunn Brownlee et al., 2017; Martinez et al., 2024). For instance, urban schools mostly host workshops on incorporating diverse perspectives into curriculum design, leading teachers to value student contributions and collaborative knowledge construction. These workshops could involve training on culturally responsive teaching, helping teachers understand and address the diverse needs of their student population (Qin, 2024; Tanase, 2021). Furthermore, urban schools often benefit from partnerships with local universities and research institutions, providing teachers with access to cutting-edge research and professional development opportunities (Kearney et al., 2020).

Conversely, rural educators, often constrained by limited budgets, reliance on traditional lecture-based methods, and limited professional development opportunities focusing on current educational research, may retain talent-oriented, absolutist views, perceiving knowledge as fixed and authority-derived (Burhan et al., 2024; Aguilar-Valdés et al., 2024; Koul & Bansal, 2023). A rural teacher, for example, primarily rely on textbooks and standardized tests, reinforcing the idea of a single, correct answer. This can be further compounded by a lack of access to updated teaching

materials and limited opportunities to collaborate with other educators, leading to a sense of isolation and a reliance on familiar, albeit potentially outdated, pedagogical approaches (Ai et al., 2022).

Such divides highlight systemic inequities, with urban environments fostering epistemic flexibility through diverse student interactions, exposure to varied cultural backgrounds, and readily available resources, while rural settings, sometimes lacking these advantages, may inadvertently reinforce hierarchical knowledge structures (Chesters & Cuervo, 2022; Tondeur et al., 2017; McCoy & Lynam, 2022). This can manifest in differences in classroom discussions, where urban classrooms encourage open debate and critical thinking, while rural classrooms might prioritize teacher-led instruction and rote memorization. For example, an urban history class analyze primary source documents from multiple perspectives, encouraging students to form their own interpretations, while a rural history class focus on memorizing dates and facts from a textbook (Han et al., 2015). The availability of broadband internet, which is often less reliable in rural areas, further exacerbates this disparity, limiting access to online learning resources and collaborative platforms (Pearce M. S., 2021). This digital divide not only affects teachers' access to professional development but also limits students' ability to engage in online research, participate in virtual field trips, and collaborate with peers from other locations, ultimately hindering their development of epistemic flexibility (Boerngen & Rickard, 2021).

Considering these disparities, a pertinent research question emerges: How do the distinct characteristics of urban and rural residential areas differentially influence the epistemological beliefs of prospective teachers?

Gendered Socialization and EB Trajectories

Gendered socialization significantly influences the development of EBs, impacting metacognitive strategies and learning approaches (Lee et al., 2021). Research suggests that women, often socialized to value collaboration and persistence, tend to exhibit relativistic, effort-driven EBs, aligning with adaptive metacognitive strategies (Bremers et al., 2025; Shoaib et al., 2021; Alkış Küçükaydın et al., 2024). For example, multiple recent studies have shown that female students are more likely to attribute academic success to hard work and consistent effort, viewing knowledge as something that can be developed over time through dedication (Malespina et al., 2022; Zanin et al., 2020; Degol et al., 2018). This perspective fosters a growth mindset, viewing challenges as opportunities for learning (Harris & Tadros, 2021). Conversely, men, influenced by competitive norms, may favor talent-centric, objectivist views, perceiving knowledge as immutable and authority-validated (Kutluca & Mercan, 2022; Bromme et al., 2010). This can manifest as a belief that intelligence is a fixed trait, leading to a focus on demonstrating innate ability rather than embracing the learning process (de Kraker-Pauw et al., 2020).

These differing EBs demonstrate cultural expectations' role in shaping epistemic cognition, with implications for pedagogical approaches (Tovar-Gálvez, 2021). Effort-oriented beliefs promote inquiry-based learning, which aligns well with the notion that knowledge is constructed through exploration and effort (Lin, 2021). In contrast, talent- centric views may perpetuate rigid instruction, hindering students' willingness to embrace challenges (O'Keefe et al., 2021). Therefore, educators should aim to foster effort-oriented beliefs by emphasizing the importance of process, providing constructive feedback, and creating a supportive learning environment (Cilalı et al., 2025). Acknowledging the influence of gendered norms in shaping EBs is crucial for creating inclusive and equitable learning experiences for all students (Ralph et al., 2023). Further research is needed to explore how gender stereotype shapes the EBs of pre-service teachers in Pakistan.

Academic Performance (CGPA) as a Predictor of EB Sophistication

Academic performance demonstrates a significant, albeit complex, relationship with the sophistication of EB (Ongowo, 2021). Research suggests that high-achieving students, utilizing self-regulated learning strategies, tend to view knowledge as malleable and effort-driven, aligning with a growth mindset (Heidarzadi et al., 2022; Yough et al., 2022). For instance, a student embracing a growth mindset sees challenges as opportunities for improvement, contrasting sharply with a fixed mindset that attributes success to innate ability (Harris & Tadros, 2021). Conversely, lower academic performance often correlates with fixed beliefs that impede adaptive learning (Svensen, 2023).

However, the predictive power of academic performance on EB sophistication is not absolute. Recent scholarship emphasizes the mediating roles of external factors, such as institutional support and curricular design (Demirbag & Bahcivan, 2021; Muis et al., 2018; Greene & Azevedo, 2007).

Demirbag & Bahcivan (2021) highlight the impact of resources like tutoring, while Muis et al. (2018) stress the importance of inquiry-based learning in fostering sophisticated epistemic beliefs, irrespective of prior academic success. Furthermore, Greene and Azevedo (2007) suggest that the specific domain of study influences the relationship between academic performance and EB.

Therefore, while academic performance provides a valuable indicator of EB sophistication, its influence is mediated by a confluence of contextual and instructional variables. This complexity necessitates further investigation into the interplay between individual achievement, learning environments, and the development of sophisticated EBs. Here a pertinent research question arises: How do difference in academic performance shapes the EBs of prospective teachers in Pakistan?

Research Questions

Despite progress three critical gaps persist: (1) limited SEM-based analyses of demographic interdependencies, (2) overreliance on Western samples, neglecting culturally nuanced EB development, and (3) underexplored talent-effort synergies in non-Western contexts. This study addresses these gaps by applying SEM to Pakistani pre-service teachers, testing how gender, residence, semester, and CGPA collectively shape EBs. By validating Schommer's framework in South Asia context, it advances a culturally responsive model of epistemic cognition, offering actionable insights for equitable teacher education reform. This study addresses these gaps through the following questions:

1. What is the structural relationship between demographic variables (semester, residence, gender, CGPA) and EB constructs (talent, effort) among pre-service teachers?
2. How do demographic variables independently influence talent- versus effort-oriented EBs?
3. Do significant differences difference exist in talent/effort constructs across academic maturation (semester level), residence, gender, or CGPA?
4. Does the SEM framework adequately explain demographic influence on EBs in a Pakistani context?

Methods Design of study

The research adopted a quantitative cross-sectional framework, using SEM to analyze structural relationships among sociodemographic parameters (academic maturation, residential context, gender, and cumulative grade point average [CGPA]) and key EB constructs (talent, effort). Cross-sectional surveys are optimal for capturing subgroup variations and testing multivariate hypotheses within a fixed timeframe, aligning with SEM's capacity to model latent constructs (Creswell & Creswell, 2018)

Participants

A stratified sample of 330 pre-service teachers was drawn from the Institute of Education and Research (IER), Punjab University, Lahore, ensuring proportional representation across academic progression or semester levels (1st–8th), residence (urban, rural), gender (male, female), and CGPA ranges (2.5–4.0). Stratification mitigated sampling bias and enabled robust subgroup comparisons (Bryman, 2016), critical for testing demographic-EB interactions.

Instrument

The Schommer Epistemological Beliefs Questionnaire (SEBQ), initially developed by Schommer-Aikins (2004), was adapted and utilized to evaluate the EBs of pre-service teachers. This 33-item Likert-scale instrument measures two distinct constructs: *talent* (items 1–16), reflecting beliefs in knowledge as a fixed, innate ability, and e*ffort* (items 17–33), emphasizing perseverance and hard work in knowledge acquisition. To ensure contextual relevance, the adaptation process included professional translation into Urdu, cultural and linguistic modifications to align items with local educational practices, and a pilot study to validate its reliability and construct validity within Pakistan's teacher education framework. Table 1 (Appendix A) provides illustrative examples of scale items.

Reliability

Previous studies have established the reliability of the SEBQ, reporting Cronbach's alpha coefficients of 0.74 for the talent dimension and 0.79 for the effort dimension (Schommer, 1990). In the present investigation, the overall Cronbach's alpha coefficient was calculated at 0.968, reflecting an exceptionally high level of internal consistency. This suggests strong inter-item correlations within each subscale, aligning with Nunnally and Bernstein's (1994) criteria for robust measurement of underlying constructs. Such consistency underscores the instrument's capacity to reliably assess

epistemological beliefs across diverse contexts and populations (Tavakol & Dennick, 2011). Detailed Cronbach's alpha values for the talent and effort constructs, as well as the full SEBQ, are provided in Table 2.

Table 2

Reliability of subscales and main scale

Items	Cronbach's alpha
Talent (1-16)	0.948
Effort (17-33)	0.929
Overall Epistemological belief	0.968

Validity

The construct validity of the SEBQ has been well-established through factor analysis, which supports the instrument's ability to accurately measure the intended constructs of epistemological beliefs (Hofer & Pintrich, 1997). The findings of the Confirmatory Factor Analysis (CFA), as depicted in Figure 3 and Table 4, offer empirical validation for the factor structure of the SEBQ. These results indicate that the SEBQ successfully reflects the multi-dimensional characteristics of EBs. In particular, it supports the distinction between different belief systems, such as the belief in the fixed nature of knowledge (talent) versus the belief in the malleability of knowledge through effort (effort).

Data Collection

The data were gathered using a structured survey distributed to pre-service teachers at the IER, University of the Punjab, Lahore. Participation was voluntary, with informed consent secured prior to administration. The consent form outlined the study's purpose, procedures, confidentiality safeguards, and participants' right to withdraw without consequence. Surveys were administered in controlled classroom settings to ensure consistency, minimize distractions, and limit researcher bias. Completion time averaged 20–30 minutes, balancing thoroughness with participant engagement (Redlich-Amirav & Higginbottom, 2014). The design prioritized accessibility for participants across diverse academic and socio-cultural backgrounds. Post-collection, data were rigorously reviewed, with demographic variables cross-referenced against SEBQ responses to examine interrelationships. This structured approach facilitated subsequent SEM to assess how gender, CGPA, academic maturation (semester level), and socio-cultural context (urban/rural) shape epistemological beliefs.

Data Analysis

Inferential Statistics

Inferential statistics were used to summarize the demographic variables (semester of study, residence, gender, CGPA) and the constructs of talent and effort. Levene's Test confirmed homogeneity of variance. The assumptions of independence of observations, linearity, absence of outliers, and adequate sample size were also assessed (Pallant, 2020). Furthermore, linearity was examined to verify that continuous variables exhibited a linear relationship, particularly relevant for regression analysis and factorial ANOVA. Outlier detection was performed using boxplots and standardized residuals, ensuring that extreme values did not unduly impact the statistical analysis. Lastly, sample size adequacy was considered, with the Central Limit Theorem supporting the use of parametric tests for large samples ($n > 30$ per group) (Pallant, 2020). Consequently, parametric statistical analyses, including independent samples t-tests and ANOVA, were conducted for each variable to examine central tendencies and variability within the sample, thereby addressing Research Question 3.

CFA

CFA was utilized to evaluate the measurement model for the constructs of talent and effort in alignment with Research Question 1. It is a sophisticated statistical method designed to test the validity of hypothesized relationships between observed variables (e.g., items from the SEBQ) and their corresponding latent constructs (e.g., talent and effort). The aim was to ensure that the data fit the proposed factor structure of the SEBQ and to confirm the instrument's validity within the context of pre-service teachers (Ozturk, 2011). This step was crucial for ensuring that the constructs being measured by the SEBQ aligned with the theoretical framework.

SEM

SEM was employed in this study as a comprehensive statistical approach to analyze the structural relationships between demographic variables (semester, residence, gender, CGPA) and epistemological beliefs (talent and effort). Unlike traditional statistical methods such as regression or ANOVA, SEM allows for the simultaneous modeling of multiple relationships, capturing both direct

and indirect effects between variables. Its implementation was customized to fit the study's objectives, particularly in examining how multiple demographic factors collectively shape epistemological beliefs rather than assessing them in isolation. This approach was necessary to answer Research Question 1 in which both CFA and SEM were utilized. CFA was implemented to assess the measurement model, verifying that the observed indicators precisely represented the underlying latent constructs of EBs (e.g., talent and effort). This step confirmed the factor structure of the SEBQ within the study's context, with results presented in Table 4 and Figure 3. Following CFA, SEM was employed to examine the direct and indirect effects of demographic variables on Talent and Effort, providing a comprehensive analysis of how these predictors influenced pre-service teachers' epistemological beliefs. The key SEM results, including standardized regression weights and path coefficients, are detailed in Table 3 and Figure 2. Additionally, the reliability analysis, which reports Cronbach's alpha values for both constructs, is presented in Table 2, demonstrating strong internal consistency and construct validity. To address Research Question 2, this examined the independent influence of demographic variables on EB. By customizing the model to the educational context of Pakistan, this study provided understanding of how demographic factors influence pre-service teachers' beliefs about knowledge acquisition, making SEM an indispensable tool in achieving the research objectives.

Model Fit Indices

Assessing model fit in SEM is crucial to ensure that the hypothesized relationships between variables align with the observed data. Model fit indices such as Chi-square (χ^2), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) provide statistical evidence regarding the adequacy of the model (Kline, 2015). A well-fitting model typically exhibits a non-significant χ^2, RMSEA values below 0.08, and CFI and TLI values above 0.90, indicating that the proposed structure accurately represents the relationships among the variables (Byrne, 2016). The inclusion of these fit indices was essential for this study, as it helped validate the conceptual model linking demographic variables (semester study, residence, gender, CGPA) to epistemological beliefs (talent and effort). This evaluation was particularly relevant in answering Research Question 4, which investigated whether the proposed SEM model provided a good fit for explaining the influence of demographic variables on epistemological beliefs. Given the complexity of examining multiple interrelated effects simultaneously, these fit indices ensured that the model's assumptions were statistically supported, enhancing the reliability and generalizability of the findings (Schermelleh-Engel et al., 2014).

All data analysis was performed using SPSS and AMOS, both of which are advanced software tools designed for conducting SEM analysis.

Results

To address the *Research Question 1*, "what is the structural relationship between demographic variables EBs constructs among pre-service teachers?" SEM and CFA were employed. These statistical techniques allowed for a comprehensive examination of how different demographic factors interact shaping EBs. CFA was performed to evaluate the measurement model, confirming that the latent constructs of EBs (e.g., talent and effort) were reliably represented by their corresponding observed indicators. Meanwhile, the outcomes of the structural relationships analyzed using SEM are presented in Table 3.

Table 3

Standardized regression weights from SEM for predicting talent and effort

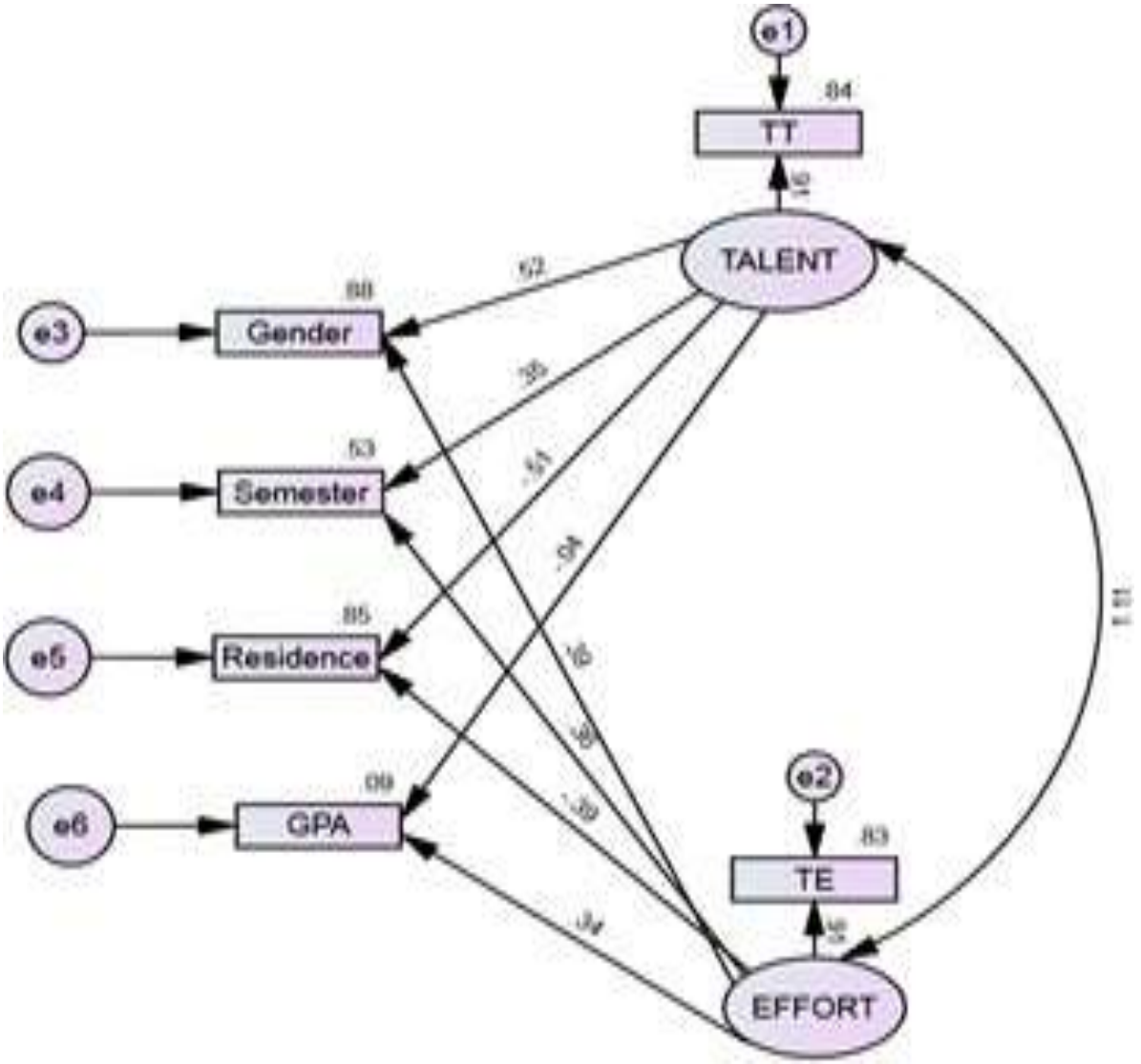
Predictor Variables	Effect on Talent (β)	Effect on Effort (β)
Gender	0.88	0.35
Residence	0.85	0.30
Semester	0.52	0.53
GPA	0.09	0.34

Table 3 illustrated the relationships between demographic variables (gender, semester, residence, and GPA) and the EB latent constructs talent and effort. The SEM analysis showed that gender (0.88) and area of residence (0.85) had strong positive effects on talent, while semester (0.52) and GPA (0.09) demonstrated moderate to weak effects. Similarly, the predictors influenced effort, with semester (0.53) and GPA (0.34) showing moderate relationships, and gender (0.35) and residence (0.30) having weaker effects. Talent and effort were highly correlated (1.11), indicating a

strong mutual dependence where changes in one construct were strongly associated with changes in the other, as represented in Figure 2. Error terms (e1, e2) accounted for the unexplained variance in talent and effort, while the observed variables explained a substantial portion of these constructs, consult Figure 2. The model highlighted the significant roles of demographic and academic variables, with gender and residence being particularly influential for talent. SEM results presented in Table 3 also align with the visual representation in Figure 2.

Figure 2

SEM Illustrating the Structural Relationships between Sociodemographic Parameters and EBs Constructs (e.g., Talent and Effort)

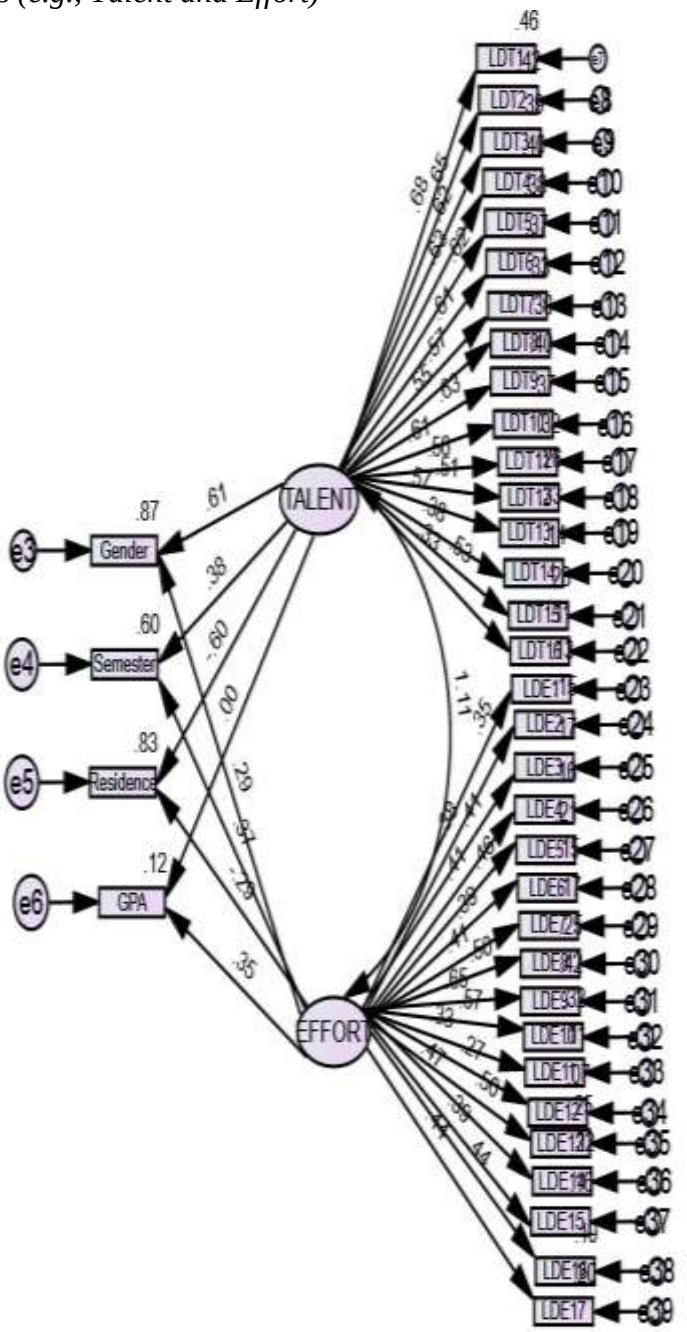


(Source: AMOS generated by authors)

To examine the structural relationships in the subsequent SEM analysis, in line with the broader objective of addressing Research Question 1 which explores how demographic variables influence EBs among pre-service teachers CFA was employed to assess the measurement model. This step ensured that the constructs of EBs (e.g., talent and effort) were reliably represented by their corresponding observed indicators. Establishing the reliability and validity of the latent variables was a critical prerequisite for advancing to the structural analysis, as outlined in the reliability section of the methodology to address Research Question 1. Figure 3 illustrates the CFA model for EB, highlighting the relationships between observed variables and their associated latent constructs.

Figure 3

CFA Model for EBs (e.g., Talent and Effort)



(Source: AMOS generated by authors)

The Figure 3 highlighted the factor loadings, showing how well the observed variables align with their respective latent constructs. The standardized loadings indicate the strength of each variable's contribution, reinforcing the reliability of the measurement model. In addition, to maintain coherence, this figure 3 is linked to Table 4 (see Appendix B) given in Appendix A, which presents the standardized regression weights derived from CFA. These values quantify the influence of demographic factors on the talent and effort constructs. By examining these weights, the table provides further empirical support for the structural relationships depicted in the figure, strengthening the study's analytical rigor.

Tale 4 (see Appendix B) illustrated the standardized regression weights revealed the relationships between the predictors (gender, semester, residence, CGPA) and the latent constructs talent and effort, as well as the loadings of individual indicators onto these constructs. Gender had the strongest positive influence on talent (β = 0.614), followed by semester (β = 0.384), while residence

had a negative influence (β = -0.601). Meanwhile, CGPA showed a negligible impact on talent (β = 0.000).

For effort, semester (β = 0.368) and CGPA (β = 0.342) had moderate positive effects, while residence had a weaker negative impact (β = -0.288). While gender had a weaker positive influence on effort (0.294) compared to talent. The factor loadings for observed variables (e.g., LDT1 to LDT16 for Talent and LDE1 to LDE17 for Effort) ranged from moderate to strong, indicating that the indicators reliably measured their respective constructs. The covariance between talent and effort was significant (225.490) with Table 5 showed a very strong interdependence between these two constructs.

Table 5

Correlation matrix of talent and effort

			Estimate
EFFORT	<-->	TALENT	1.114

Table 5 presents the correlation between effort and talent constructs of EB, with an estimated value of 1.114, indicating a strong positive relationship between these two latent constructs. A correlation value greater than 1 suggests that talent and effort are highly interdependent, implying that students who exhibit higher epistemological beliefs in talent are also likely to emphasize the role of effort in their learning process. Overall, the results indicated that gender and semester were strong predictors of talent, while semester and CGPA were more influential for effort, with talent and effort being highly correlated.

To answer the *research question 2* like "how do demographic variables (semester, residence, gender, CGPA) independently influence the constructs of talent and effort in epistemological beliefs?" multiple regression analysis was conducted. Table 6 mentioned the results and relevant explanation below:

Table 6

Multiple regression analysis

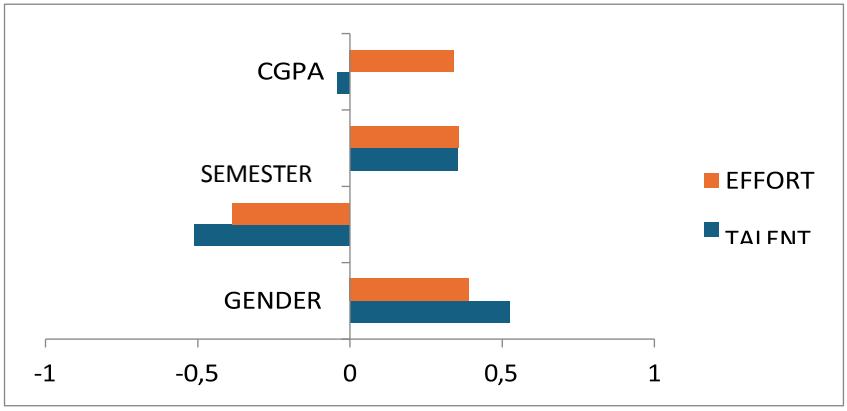
			Estimate
Total Talent	<---	TALENT	0.915
Total Effort	<---	EFFORT	0.913
Gender	<---	TALENT	0.524
Semester	<---	TALENT	0.354
Residence	<---	TALENT	-0.512
			Estimate
CGPA	<---	TALENT	-0.041
Gender	<---	EFFORT	0.391
Semester	<---	EFFORT	0.355
Residence	<---	EFFORT	-0.386
CGPA	<---	EFFORT	0.342

Table 6 illustrated that the standardized regression weights indicate the relationships between the predictors (gender, semester, residence, CGPA) and the latent constructs (talent and effort) in the model. Gender had a strong positive effect on talent (β = 0.524) and a moderate positive effect on effort (β = 0.391), showing its significant role in influencing these constructs.

Semester also positively influenced talent (β = 0.354) and effort (β = 0.355), indicating a consistent moderate effect. Residence had a negative impact on both talent (β = -0.512) and effort (β = -0.386). CGPA had a minimal negative effect on talent (β = -0.041) but a moderate positive effect on effort (β = 0.342). The covariance between talent and effort (estimate = 225.488, $p = <0.001$) was highly significant, highlighting a strong interdependence between these two constructs. Overall, gender and semester were the strongest positive predictors, while residence negatively influenced both talent and effort. Figure 4 visually represented the comparative influence of sociodemographic factors on the EB constructs (e.g., talent and effort).

Figure 4

Influence of Sociodemographic Parameters on EB Constructs (e.g., Talent & Effort)



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To investigate *Research Question 3*, which examines whether significant differences exist in the talent and effort constructs across academic progression (semester level), residential background, gender, or cumulative grade point average (CGPA), independent samples t-tests and one-way ANOVA were performed. These analyses were conducted to assess variations in relation to the specified sociodemographic factors and EB constructs. The results are systematically presented across multiple tables for clarity and detailed examination.

Specifically, Table 7 presents the findings related to gender differences, while Table 8 focuses on residence-based comparisons. academic maturation (semester level) was analyzed separately for the talent construct of epistemological beliefs in Table 9 and Table 10, and for the effort construct in Table 11 and Table 12. Moreover, a comprehensive overview of semester study effects is further detailed in Table 13 and Table 14.

In relation to academic performance, variations in the talent construct based on cumulative grade point average (CGPA) were analyzed and detailed in Tables 15 and 16. Similarly, the influence of CGPA on the effort construct is presented in Tables 17 and 18. Lastly, Tables 19 and 20 offer a comprehensive overview of CGPA's impact on EBs. These analyses offer valuable insights into how sociodemographic parameters shape the development of EBs (e.g., talent and effort) among pre-service teachers.

Table 7

Comparison of male and female pre-service teachers' perception on the construct of talent, effort and overall epistemological beliefs

	Male			Female						
Epistemological Beliefs	N	*M*	*SD*	N	*M*	*SD*	*df*	*t*	*p*	Cohen's *d*
Talent	153	42.22	10	177	70.23	4.46	203.28	-31.98	<.001	7.57
Effort	153	48.25	9.3	177	75.48	3.91	197.53	-33.55	<.001	6.98
Overall, EB	153	90.48	18.06	177	145.7	7.1	192.40	-35.52	<.001	13.35

As shown in Table 7, the outcomes of the independent samples t-tests indicated statistically significant differences in the talent and effort constructs between male and female participants across all three measurement scales. For the first construct, females (M = 70.23) scored significantly higher than males (M = 42.22). Similarly, for the second construct, females (M = 75.48) also outperformed males (M = 48.25). Lastly, for the overall constructs, females (M = 145.715) achieved significantly higher scores than males (M = 90.48). The consistently lower scores for males and the significant p-values across all comparisons suggest that gender plays a crucial role in these constructs, with females demonstrating significantly higher levels of talent and effort related epistemological beliefs than males in all cases. Figure 5 illustrated the differences in talent, effort, and EBs between male and female participants, highlighting those female participants demonstrated higher levels across all constructs, suggesting a more effort-driven approach to knowledge acquisition.

Figure 5

Comparison of Talent, Effort, and Overall EBs between Male and Female Participants

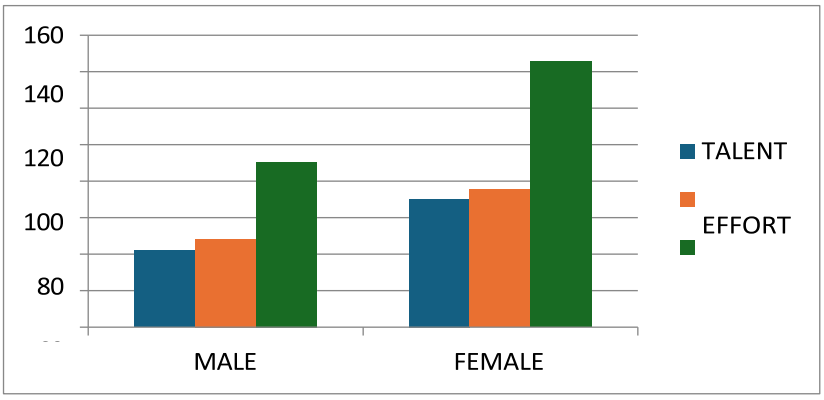

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Table 8

Comparison of urban and rural pre-service teachers' perception on the construct of talent, effort and overall epistemological beliefs

	Rural			Urban					
Epistemological Beliefs	N	*M*	*SD*	N	*M*	*SD*	*df*	*t*	*p*	Cohen's *d*
Talent	147	128.1	6.5	183	69.50	9.7	244.44	29.43	<.001	8.09
Effort	147	47.95	6.0	183	74.83	8.79	248.96	31.55	<.001	7.39
Overall EB	147	89.94	11.74	183	89.94	17.06	294.31	32.88	<.001	14.36

As presented in Table 8, the findings from the independent samples t-tests demonstrated statistically significant differences in the talent and effort constructs between pre-service teachers from urban and rural backgrounds across overall EBs and its constructs (e.g., talent and effort). For the first construct, rural students (M = 128.15) scored significantly higher than urban students (M = 69.508). In the second construct, urban students (M = 74.83) outperformed rural students (M = 47.95). For the third construct, urban students (M = 144.33) scored significantly higher than rural students (M = 89.94). The consistently significant p-values across all measures indicate that residence (urban vs. rural) plays a significant role in determining the constructs of talent and effort. Rural students excel in the talent, whereas urban students outperform in the effort construct and overall epistemological beliefs. Figure 6 illustrated the differences in talent, effort, and EBs between urban and rural area participants.

Figure 6

Comparison of Talent, Effort, and Overall EBs between Urban and Rural Participants

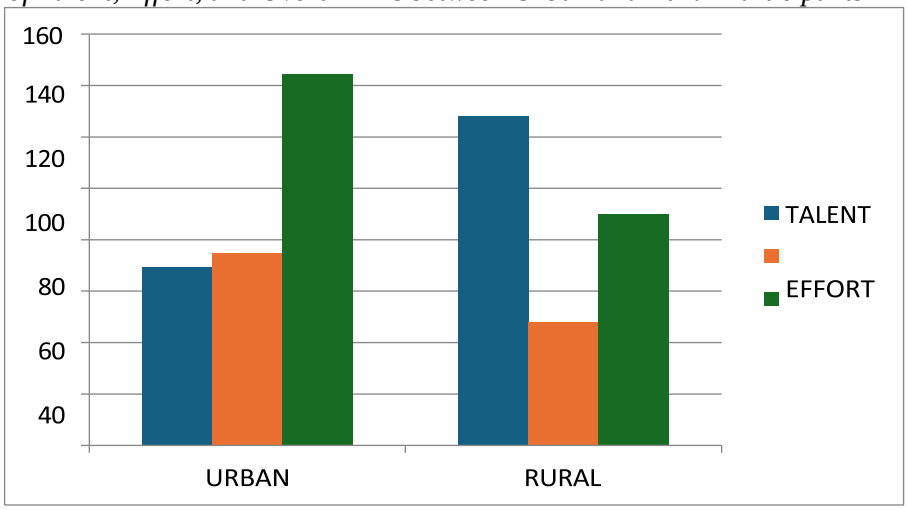

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Table 9

Univariant analysis of variance of pre-service teacher's perception on talent construct of epistemological belief among academic maturation (semester levels)

Sources	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between groups	39664.978	3	13221.659	133.550	<.001
Within the groups	43537.146	326	133.550		
Total	83202.124	329			

Table 10

LSD post-hoc test for multiple comparisons for pre-service teacher's perception on talent construct of epistemological belief among academic maturation (semester levels)

Comparison	Mean difference	Sig.
1st Vs. 2nd semester	-13.52368	<.001
1st Vs. 3rd semester	-25.66840	<.001
1st Vs. 4th semester	-31.35556	<.001
2nd Vs. 3rd semester	12.14472	<.001
2nd Vs. 4th semester	-17.83188	<.001
3rd Vs. 4th semester	-5.68715	<.001

The univariate analysis of variance (ANOVA) results presented in Table 9 revealed significant differences in pre-service teachers' perceptions of the talent construct of epistemological beliefs across semesters. The between-group variability, with a mean square value of 13221.659, was substantially greater than the within-group variability, which had a mean square value of 133.550. This disparity yielded a highly significant F-statistic. While Table 10 illustrated the post-hoc comparisons using the LSD test showed statistically significant differences across all pairwise semester comparisons. The largest mean difference was observed between the 1st (M= -13.52368, p= <.001) and 4th semesters (M=-31.35556, p= <.001), indicating substantial growth in the talent construct perception over time. Smaller but still significant differences were found between adjacent semesters, such as the 1st (M=-13.52368, p= <.001) and 2nd semesters (M=-25.66840, p= <.001) and the 3rd and 4th semesters (M= 5.68715, p= <.001), suggesting a gradual and consistent development in this construct throughout the semesters.

Table 11

Univariant analysis of variance of pre-service teacher's perception on effort construct of epistemological belief among semesters

Sources	Sum of Squares	Df	Mean Square	F	Sig.
Between groups	35928.378	3	11976.126	95.467	<.001
Within the groups	40895.928	326	125.448		
Total	76824.306	329			

Table 12

LSD post-hoc test for multiple comparisons for pre-service teacher's perception on effort construct of epistemological belief among semester levels (academic maturation)

Comparison	Mean difference	Sig.
1st Vs. 2nd semester	-10.59411	<.001
1st Vs. 3rd semester	-23.08796	<.001
1st Vs. 4th semester	-29.06296	<.001
2nd Vs. 3rd semester	-12.49385	<.001
2nd Vs. 4th semester	-12.49385	<.001
3rd Vs. 4th semester	-5.97500	<.001

The univariate analysis of variance (ANOVA) analysis results presented in Table 11 revealed significant differences in pre-service teachers' perceptions of the effort construct of epistemological beliefs across semesters. The between-group variability, reflected by a mean square value of 11976.126, was significantly higher than the within-group variability, which had a mean square value of 125.448. This substantial difference produced a highly significant F-statistic. The LSD post-hoc test results illustrated in Table 12 demonstrated statistically significant differences across all pairwise comparisons. The largest mean difference was observed between the 1st and 4th semesters (M=-29.06296, p= <.001), indicating a substantial increase in the effort construct perception over time.

Smaller but significant differences were also observed between adjacent semesters, such as the 1st and 2nd semesters (M=-10.59411, p= <.001) and the 3rd and 4th semesters (M=-5.97500, p= <.001), highlighting a consistent and progressive development in perceptions of effort throughout the semesters.

Table 13

Univariant analysis of variance of pre-service teacher's perception on epistemological beliefs among semester levels (academic maturation)

Sources	Sum of Squares	Df	Mean Square	F	Sig.
Between groups	150850.40	3	50283.469	103.75	<.001
Within the groups	157987.66	326	484.625		
Total	308838.07	329			

The univariate analysis of variance (ANOVA) results presented in Table 13 revealed significant differences in the perception of epistemological beliefs among pre-service teachers across different semesters. The between-group variability is substantial, with a mean square of 50283.469 compared to 484.625 for within-group variability. The F-statistic of 103.75 is highly significant indicating that the academic maturation (semester level) influences the perception of epistemological beliefs. These results suggested that perceptions vary meaningfully across the groups, necessitating a post-hoc analysis to identify specific differences between semesters.

Table 14

LSD post-hoc test for multiple comparisons for pre-service teacher's perception on epistemological beliefs among semester levels (academic maturation)

Comparison	Mean difference	Sig.
1st Vs. 2nd semester	-24.11779	<.001
1st Vs. 3rd semester	-48.75637	<.001
1st Vs. 4th semester	-60.41852	<.001
2nd Vs. 3rd semester	-24.63858	<.001
2nd Vs. 4th semester	-36.30073	<.001
3rd Vs. 4th semester	-11.66215	<.001

The LSD post-hoc test results illustrated in Table 14 provided further clarity by comparing pairs of semesters and highlighted significant differences in epistemological beliefs. All comparisons yield statistically significant differences indicating that beliefs change progressively as students advance through their semesters. The largest difference is observed between the 1st and 4th semesters (M= -60.41852, p= <.001), reflecting a substantial growth in perceptions over time. Smaller but significant differences are also noted between adjacent semesters, such as the 1st and 2nd (M=-24.11779, p= <.001) semesters and the 3rd and 4th semesters (M=-11.66215, p= <.001). These results emphasized a consistent and meaningful development in epistemological beliefs as students move through their academic journey.

Table 15

Univariant analysis of variance of pre-service teacher's perception on talent construct of epistemological belief among CGPA

Sources	Sum of Squares	Df	Mean Square	F	Sig.
Between groups	10149.255	2	5074.627	22.715	<.001
Within the groups	73052.870	327	223.403		
Total	83202.124	329			

Table 16

LSD post-hoc test for multiple comparisons for pre-service teacher's perception on effort construct of epistemological belief among CGPA

Comparison	Mean difference	Sig.
1.5-2.9 Vs 3.0-3.5	-3.82141	<.001
1.5-2.9 Vs 3.6-4.0	-13.34508	<.001
3.0-3.5 Vs 3.6-4.0	-9.52366	<.001

The univariate analysis of variance (ANOVA) results presented in Table 15 demonstrated significant differences in pre-service teachers' perceptions of the talent construct of epistemological belief among CGPA groups. The between-group variability (Mean Square = 5074.627) was substantially larger than the within-group variability (Mean Square = 223.403), resulting in a highly

significant F-statistic. While Table 16 post-hoc comparisons results using the LSD test revealed significant differences among all CGPA group comparisons. The largest mean difference was observed between the 1.5–2.9 CGPA group and the 3.6–4.0 CGPA group, indicating that students with higher CGPAs had significantly greater perceptions of talent. Additionally, significant differences were found between the 1.5–2.9 and 3.0–3.5 groups and between the 3.0–3.5 and 3.6–4.0 groups. These results suggested a progressive increase in the perception of talent as CGPA increased.

Table 17

Univariant analysis of variance of pre-service teacher's perception on effort construct of epistemological belief among CGPA

Sources	Sum of Squares	Df	Mean Square	F	Sig.
Between groups	7967.571	2	3983.786	18.919	<.001
Within the groups	68856.735	327	210.571		
Total	76824.306	329			

Table 18

LSD post-hoc test for multiple comparisons for pre-service teacher's perception on effort construct of epistemological belief among CGPA

Comparison	Mean difference	Sig.
1.5-2.9 Vs 3.0-3.5	-.46681	<.001
1.5-2.9 Vs 3.6-4.0	-10.26584	<.001
3.0-3.5 Vs 3.6-4.0	-9.79903	<.001

The univariate analysis of variance (ANOVA) illustrated in Table 17 indicated significant differences in pre-service teachers' perceptions of the effort construct of epistemological belief among CGPA groups. The between-group variability (Mean Square = 3983.786) was much larger than the within-group variability (Mean Square = 210.571), resulting in a highly significant F-statistic. Furthermore, post-hoc comparisons results illustrated in Table 18 using the LSD test revealed significant differences among all CGPA group comparisons. The largest mean difference was observed between the 1.5–2.9 CGPA group and the 3.6–4.0 CGPA group, indicating that students with higher CGPAs had significantly higher perceptions of effort. Similarly, significant differences were noted between the 1.5–2.9 group and the 3.0–3.5 group and between the 3.0–3.5 group and the 3.6–4.0 group. These results suggest a progressive increase in the perception of effort as CGPA increases.

Table 19

Univariant analysis of variance of pre-service teacher's perception on both constructs of epistemological belief among CGPA

Sources	Sum of Squares	Df	Mean Square	F	Sig.
Between groups	35666.372	2	17833.186	21.347	<.001
Within the groups	273171.701	327	835.387		
Total	308838.073	329			

Table 20

LSD post-hoc test for multiple comparisons for pre-service teacher's perception on effort construct of epistemological belief among CGPA

Comparison	Mean difference	Sig.
1.5-2.9 Vs 3.0-3.5	-4.28822	<.001
1.5-2.9 Vs 3.6-4.0	-23.61092	<.001
3.0-3.5 Vs 3.6-4.0	-19.32270	<.001

The univariate analysis of variance (ANOVA) results presented in Table 19 showed significant differences in pre-service teachers' perceptions of both constructs of epistemological belief among CGPA groups. The between-group variability (Mean Square = 17,833.186) was much larger than the within-group variability (Mean Square = 835.387), resulting in a highly significant F-statistic. Moreover, Table 20 post-hoc comparisons results using the LSD test revealed significant differences among all CGPA group comparisons. The largest mean difference was found between the 1.5–2.9 CGPA group and the 3.6–4.0 CGPA group, indicating a substantial increase in epistemological belief constructs among students with higher CGPAs. Similarly, significant differences were noted between the 1.5–2.9 and 3.0–3.5 groups and the 3.0–3.5 and 3.6–4.0 groups, demonstrating a progressive enhancement in perceptions of these constructs as CGPA increased.

Lastly, to answer the *research question 4* like "does the proposed SEM model provide a good fit for explaining the influence of demographic variables on epistemological beliefs among pre-service teachers?" the model fit statistics were explored as given below in Table 21.

Table 21

Evaluation of model fit using key fit indices

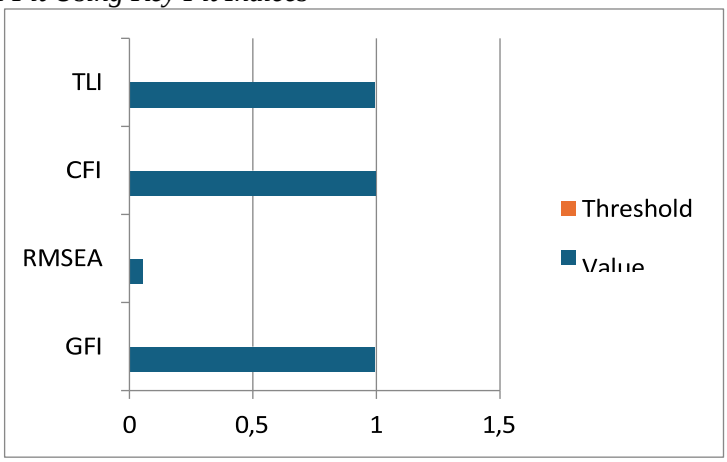
Fit Index	Value	Threshold
X2/df	7.953	< 3.00
GFI	.99	< 1
TLI	.99	> 0.95
CFI	.99	> 0.95
RMSEA	.05	< 0.06

The Table 21 illustrated the model fit statistics for the structural equation model evaluation using various indices, including chi-square, GFI, TLI, CFI, and RMSEA. The chi-square value for the default model was 7.953 with a p-value of 0.093, indicating that the model's fit was acceptable since the p-value exceeded 0.05. The Goodness of Fit Index (GFI) was 0.992, indicating an excellent model fit, as values approaching 1 are regarded as optimal.

Additionally, the Tucker-Lewis Index (TLI) and Comparative Fit Index (CFI) were 0.993 and 0.998, respectively, both surpassing the widely accepted threshold of 0.95, thereby reinforcing the model's robust fit. Furthermore, the Root Mean Square Error of Approximation (RMSEA) was 0.055, with a confidence interval spanning from 0.000 to 0.111 and a p-value of 0.370 for the PCLOSE test. This indicated a good fit, as RMSEA values below 0.06 reflect a well-fitting model. Overall, the model exhibited excellent fit across multiple indices, supporting its suitability for explaining the relationships among the variables. Figure 7 illustrated visual representation of Table 21 indicating model fit indices against threshold.

Figure 7

Evaluation of Model Fit Using Key Fit Indices



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Discussion

This study represents the first comprehensive investigation into the sociodemographic determinants of EBs among pre-service teachers in Pakistan, employing SEM to disentangle complex interdependencies between demographic variables and EB constructs. The findings illuminate critical pathways through which gender, residential context, academic maturation (semester level), and academic performance (CGPA) shape talent- versus effort-oriented conceptions of knowledge, offering novel insights into EB formation within a culturally distinct, understudied South Asian context. Below, we contextualize these results within theoretical frameworks, discuss their implications for teacher education, and propose actionable strategies for systemic reform.

The robust positive association between female gender and effort-oriented EBs ($\beta = 0.391$, $p < 0.001$) aligns with global studies emphasizing gendered socialization's role in epistemic development (Bremers et al., 2025; Shoaib et al., 2021). Pakistani women, socialized to prioritize perseverance and collaborative learning, disproportionately endorsed effort-driven beliefs, viewing knowledge as malleable through sustained engagement a pattern mirroring findings from Turkey (Alkış Küçükaydın et al., 2024) and Iran (Heidarzadi et al., 2022). Conversely, male pre-service

teachers exhibited stronger talent-oriented beliefs (β = 0.524, $p < 0.001$), reflecting cultural norms valorizing innate ability as a marker of intellectual authority. This dichotomy underscores the need to challenge gender stereotypes in teacher education, as talent-centric views may perpetuate rigid, transmission-based pedagogies ill-suited for diverse classrooms (O'Keefe et al., 2021).

Residential context emerged as a pivotal predictor, with urban pre-service teachers demonstrating significantly higher effort-oriented EBs (β = -0.386, $p < 0.001$). Urban environments, characterized by access to technology, interdisciplinary collaborations, and progressive pedagogies (e.g., inquiry-based/project-based learning), appear to foster epistemic flexibility and constructivist orientations a trend observed in China (Tong et al., 2024) and South Africa (Truscott & Obiwo, 2021). Conversely, rural participants' reliance on traditional, teacher-centered methods (Burhan et al., 2024) correlated with talent-oriented beliefs, likely due to limited exposure to innovative practices and resource constraints. These disparities mirror Pakistan's systemic inequities, where rural schools often lack broadband access and professional development opportunities (Shoaib et al., 2021), perpetuating hierarchical knowledge structures.

Academic progression (semester level) exerted the most consistent influence across EB constructs, with advanced semesters correlating with effort-driven beliefs (β = 0.355, $p < 0.001$). This aligns with the Reflective Judgment Model (King & Kitchener, 2004), wherein prolonged engagement with pedagogical theories and practicum experiences facilitates transitions from dualistic to evaluativist epistemologies. For instance, fourth-semester pre-service teachers, having designed differentiated lesson plans, were more likely to view knowledge as contextually negotiated a progression absent in novices. Similarly, higher CGPA predicted effort-oriented EBs (β = 0.342, $p < 0.001$), reinforcing the interplay between metacognitive strategies, self-regulated learning, and epistemic growth (Greene & Azevedo, 2007). However, CGPA's minimal impact on talent beliefs (β = -0.041) suggests academic achievement alone cannot dismantle fixed ability mindsets without explicit mindset interventions (Yeager et al., 2019).

The strong covariance between talent and effort (1.114, $p < 0.001$) challenges binary classifications of EBs, suggesting Pakistani pre-service teachers integrate both constructs dialectically. While effort-dominated, participants acknowledged innate ability's role a nuance reflecting collectivist cultural values that harmonize individual perseverance with communal notions of "giftedness." This finding complicates Schommer's (1990) continuum, advocating for culturally hybrid EB models in non-Western contexts.

Theoretical Advancements and Practical Implications for Teacher Education

The findings of this study carry significant theoretical and practical implications for understanding the sociocultural dynamics of EBs in teacher education. Theoretically, the research advances Schommer's (1990) framework by demonstrating how systemic inequities and cultural norms in non-Western contexts modulate EB development. The strong association between urban residency and effort-oriented EBs underscores the role of infrastructural access and pedagogical exposure in fostering epistemic flexibility, challenging universalist assumptions about EB trajectories. Similarly, the gendered divergence in EBs—where women disproportionately endorsed effort-driven beliefs—highlights how patriarchal norms and socialization processes shape epistemic cognition, a dimension often overlooked in Western-centric models. These insights advocate for revising EB theories to integrate *structural epistemologies*, which account for how macrosystemic factors (e.g., urban-rural resource disparities, gendered expectations) co-construct belief systems. Furthermore, the dialectical interdependence of talent and effort constructs in Pakistan's collectivist context complicates the naive-sophisticated EB continuum, urging scholars to develop hybrid models that reflect non-binary, culturally situated epistemologies. Such theoretical refinements are critical for global EB research, ensuring frameworks are both inclusive and responsive to the Global South's unique sociodemographic landscapes.

Practically, the study offers actionable strategies for reforming teacher education programs in Pakistan and analogous contexts. Policymakers must prioritize bridging urban-rural divides by equipping rural institutions with technology, inquiry-based curricula, and professional development opportunities to counteract talent-centric pedagogies. Gender-responsive interventions, such as deconstructing ability stereotypes through reflective teaching modules, are essential to mitigate male pre-service teachers' fixed mindset inclinations. Additionally, academic maturation's robust correlation with sophisticated EBs underscores the need for semester-specific training: early semesters

could integrate growth mindset workshops, while advanced semesters might focus on critical praxis, empowering educators to address systemic biases in knowledge dissemination. Leveraging high-CGPA students as peer mentors could further institutionalize effort-oriented strategies, fostering collaborative learning cultures. Finally, the findings advocate for national policies that address structural inequities (e.g., broadband access in rural schools, gender-inclusive pedagogy mandates), ensuring epistemic development aligns with Sustainable Development Goal 4's equity objectives. By embedding these implications into teacher training frameworks, stakeholders can cultivate a generation of educators equipped to navigate diverse classrooms with adaptive, evidence-based pedagogies.

Limitations and Future Research Directions

While this study advances understanding of sociodemographic influences on EBs in Pakistan, several limitations warrant attention. First, the cross-sectional design, though efficient for modeling structural relationships, precludes causal inferences about how EBs evolve longitudinally. Epistemic beliefs are dynamic, shaped by cumulative educational experiences (e.g., practicum placements, mentorship), which a snapshot survey cannot fully capture.

Future research should adopt longitudinal mixed methods designs, tracking pre-service teachers from enrollment through graduation to map critical junctures (e.g., pedagogy courses, classroom internships) that catalyze epistemic shifts. Such designs could also disentangle bidirectional relationships for instance, whether effort-oriented EBs drive academic success (CGPA) or vice versa.

Second, reliance on self-reported data introduces risks of social desirability bias, particularly in contexts like Pakistan, where cultural norms may incentivize participants to overstate effort-centric beliefs aligned with institutional expectations. Triangulating surveys with qualitative methods (e.g., classroom observations, reflective journals, and semi-structured interviews) could reveal discrepancies between professed beliefs and enacted pedagogical practices. For example, a teacher may endorse effort-oriented EBs in surveys yet default to lecture-based methods due to systemic constraints (e.g., overcrowded classrooms, exam pressures).

Third, while stratified sampling ensured diversity within Punjab University's Institute of Education and Research, the single institution focus limits generalizability. Pakistan's educational landscape is highly heterogeneous, with stark regional disparities between provinces (e.g., Sindh's urban hubs vs. Balochistan's rural schools). Replicating this study across multiple teacher training institutions particularly in conflict-affected or linguistically diverse regions would clarify how localized sociopolitical factors (e.g., provincial curricula, language policies) modulate EB development. Comparative studies across South Asia (e.g., India, Bangladesh) could further illuminate shared cultural dynamics, such as collectivist values or postcolonial legacies, that shape epistemic cognition.

Fourth, while the analysis focused on four key sociodemographic variables, unexamined confounders such as socioeconomic status (SES), parental education, and prior schooling quality likely mediate EB formation. Students from affluent urban families, for instance, may have had early exposure to inquiry-based learning, predisposing them to effort-oriented beliefs irrespective of current residence. Future studies should incorporate SES indicators (e.g., household income, parental occupation) and educational capital (e.g., private vs. public schooling) to disentangle intersecting privileges.

Finally, though the Urdu-adapted SEBQ demonstrated high reliability, rigorous cross-cultural validation remains incomplete. While translation protocols followed best practices (e.g., back-translation, pilot testing), certain items (e.g., "Knowledge is handed down by authorities") may carry divergent connotations in Pakistan's hierarchical educational culture compared to Western contexts. Establishing measurement invariance through multinational comparisons would strengthen the scale's cross-cultural applicability. Additionally, integrating indigenous epistemic constructs such as *ilm* (knowledge with moral dimensions in Islamic contexts) could yield a more holistic understanding of EBs in Muslim-majority societies.

Conclusion

This study pioneers a contextualized understanding of EB development among pre-service teachers in Pakistan, challenging the universality of Western-centric frameworks by revealing how sociocultural, structural, and systemic forces uniquely shape conceptions of knowledge. The interplay between talent and effort-oriented beliefs strongly mediated by gender socialization, urban-rural divides,

academic maturation, and achievement underscores the need for hybrid EB models that account for non-Western epistemologies, where communal values, structural inequities, and individual agency dialectically coexist. Practically, the findings demand transformative reforms in Pakistan's teacher education landscape: bridging urban-rural gaps through equitable resource distribution and technology-integrated professional development, embedding gender-responsive pedagogies to dismantle ability stereotypes, and redesigning curricula to foster growth mindsets across academic progression. Theoretically, the study advances *structural epistemologies* as a critical lens, emphasizing how macrosystemic barriers (e.g., digital divides, patriarchal norms) and cultural narratives modulate epistemic cognition, urging global EB research to prioritize marginalized contexts in its quest for inclusivity. As Pakistan aligns with Sustainable Development Goal 4 (quality education), cultivating educators with adaptive, effort-driven EBs is not merely a pedagogical imperative but a social justice endeavor one that equips teachers to challenge cycles of epistemic inequity in classrooms and communities. Future research must expand to multi-site, longitudinal designs across South Asia, integrate indigenous knowledge systems (e.g., *ilm* in Islamic pedagogy), and explore intersections with socioeconomic factors, ensuring EB frameworks reflect the pluriversality of human learning and empower educators as agents of equitable societal transformation.

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Appendix A

Table 1 *Example Items SEBQ*

Talent
1. The most important part of scientific work is original thinking; thus, knowledge is always changing.
2. A course in study skills would probably be valuable.
3. The really smart students do not have to work hard to do well in school.
4. If you are going to be able to understand something, it will make sense to you the first time you hear it.
Effort
1. If I get time to reread a textbook chapter, I get a lot more out of it the second time.
2. Being a good student generally involves memorizing facts.
3. To me, studying means getting the big ideas from the text rather than details.
4. Being a good student generally involves memorizing facts.

Appendix B

Table 4 *Standardized regression weights according to CFA*

Variables			**Estimate**
Gender	<---	TALENT	0.614
Semester	<---	TALENT	0.384
Residence	<---	TALENT	-0.601
CGPA	<---	TALENT	0.000
Gender	<---	EFFORT	0.294
Semester	<---	EFFORT	0.368
Residence	<---	EFFORT	-0.288
CGPA	<---	EFFORT	0.349
LDT1	<---	TALENT	0.683
LDT2	<---	TALENT	0.648
LDT3	<---	TALENT	0.586
LDT4	<---	TALENT	0.648
LDT5	<---	TALENT	0.623
LDT6	<---	TALENT	0.598
LDT7	<---	TALENT	0.557
LDT8	<---	TALENT	0.575
LDT9	<---	TALENT	0.617
LDT10	<---	TALENT	0.596
Variables			**Estimate**
LDT11	<---	TALENT	0.571
LDT12	<---	TALENT	0.522
LDT13	<---	TALENT	0.545
LDT14	<---	TALENT	0.314
LDT15	<---	TALENT	0.531
LDT16	<---	TALENT	0.303
LDE1	<---	EFFORT	0.315
LDE2	<---	EFFORT	0.413
LDE3	<---	EFFORT	0.450
LDE4	<---	EFFORT	0.386
LDE5	<---	EFFORT	0.477
LDE6	<---	EFFORT	0.422
LDE7	<---	EFFORT	0.367
LDE8	<---	EFFORT	0.481
LDE9	<---	EFFORT	0.666
LDE10	<---	EFFORT	0.598
LDE11	<---	EFFORT	0.279
LDE12	<---	EFFORT	0.249
LDE13	<---	EFFORT	0.503
LDE14	<---	EFFORT	0.489
LDE15	<---	EFFORT	0.369
LDE16	<---	EFFORT	0.443
LDE17	<---	EFFORT	0.463