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The Relationship of Personality Traits, Psychological Flexibility, and Curiosity with Cognitive Acceptance for Presenting a Structural Equation Model

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ABSTRACT

Objective: This study aimed to examine the psychometric properties of the Cognitive Acceptance Questionnaire (Kromrey & Rose, 2016) using the Graded Response Item Response Theory (IRT) model and to evaluate a structural equation model predicting cognitive acceptance based on psychological flexibility, personality traits, and curiosity among university students.

Methods: A cluster sampling method was employed across two phases, involving 491 participants for psychometric evaluation and 581 participants for structural equation modeling (SEM). Data were gathered using the Cognitive Acceptance Questionnaire, the Psychological Flexibility Scale, the 60-item NEO Five-Factor Inventory, and the Curiosity and Exploration Inventory. Analyses included content validity indices, IRT graded response modeling, classical test theory (CTT) metrics, marginal reliability, and path analysis.

Results: Psychometric findings indicated satisfactory content validity, acceptable item parameters, appropriate factor loadings, high marginal reliabilities (0.80 to 0.90), and strong internal consistencies (Cronbach's α ranging from .778 to .899). Structural equation modeling revealed that psychological flexibility, personality traits, and curiosity had significant positive relationships with cognitive acceptance at the 99% confidence level ($p <$ .01), with path coefficients of .36, .50, and .17, respectively. The adjusted coefficient of determination indicated that 79% of the variance in cognitive acceptance was explained by these predictors (Adjusted $R^2 = .790$).

Conclusions: The Cognitive Acceptance Questionnaire demonstrates robust psychometric validity and reliability under both CTT and IRT frameworks. Moreover, psychological flexibility, personality traits, and curiosity serve as vital determinants of cognitive acceptance.

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Introduction

Intellectual humility is a mindset, disposition, or personality trait that guides our responses to evidence, as we seek the truth and strive to avoid errors. Over the years, intellectual humility has been examined as a virtue from numerous perspectives. Unlike arrogant individuals, humble people tend to evaluate their abilities and achievements more accurately. They acknowledge their flaws and limitations, remain open to contradictory information, exhibit reduced self-focus in favor of focusing on others, and appreciate the value in all things (Alfano et al., 2017).

With the rise of positive psychology, intellectual humility has emerged as one of the most exciting areas in psychological research, as it has been shown to have a widespread impact on human functioning. Nevertheless, the study of intellectual humility is still in its infancy, and progress in understanding this construct has been hindered by its diverse and multifaceted definitions and measurements. Furthermore, contradictory findings also exist within this field of literature.

(Krumrei & Rouse, 2016). While humility can be considered a virtue that promotes being a good person, intellectual humility can be classified as an epistemic virtue that promotes being a good thinker. Diverse theoretical foundations have led to various definitions of intellectual humility. Intellectual virtues have been defined as the absence of their counterparts, such as intellectual pride, adding that intellectual humility becomes a virtue when there is a lack of concern for one's own intellectual status. Another conceptualization of intellectual humility involves the Aristotelian mean between two vices, such as maintaining an accurate view of one's cognitive capacities as a mean between the two extremes of intellectual arrogance and intellectual diffidence.

Therefore, although intellectual humility calls for openness to new ideas (McElroy et al., 2014) and a willingness to change one's perspective if necessary (Hopkin, Hoyle, & Toner, 2014), it does not involve constantly capitulating to others. An intellectually humble individual can strike an appropriate balance between dogmatically rejecting the opposing views of others and conceding too quickly in the face of intellectual conflict. Thus, intellectual humility involves the ability to hold one's beliefs with conviction while remaining open to alternative evidence. This ability stems from an awareness of epistemic limitations and the fallibility of one's knowledge, as well as the capacity to distinguish what one knows from what one does not know. Other theories emphasize that knowledge and the strength of a belief should be derived from an individual's epistemic position rather than other sources.

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According to Bąk et al. (2022), selected findings from empirical studies on the construct of intellectual humility indicate an association between personality traits and intellectual humility. Among the various approaches to defining intellectual humility, those most closely aligned with personality psychology posit that intellectual humility is a relatively stable disposition that characterizes individual differences. Therefore, examining the relationships between intellectual humility and other stable personality dispositions is essential. Researchers who compare intellectual humility with various personality traits treat them, on the one hand, as a reference point, and on the other hand, as domains that enable the identification of intellectual humility as an independent phenomenon (Bąk et al., 2022). Certain semantic elements of the intellectual humility construct are similar to various characteristics of the Five-Factor Model of personality. The most evident of these is the conceptual relationship between intellectual humility and openness to experience.

Despite these useful clues in the personality literature, it seems important to avoid an overly simplistic association of intellectual humility with specific personality traits. Even traits that appear to be associated with intellectual humility can pose their own risks. For instance, a trait such as openness to experience can easily become a barrier to intellectual humility if it leads to a kind of noncommittal intellectual paralysis (Church & Samuelson, 2017).

Generally, individuals tend to be far more confident in themselves than they ought to be. Extensive research indicates that individuals exhibit a pervasive overconfidence bias, wherein they overestimate their performance on various tasks, believe they are more favorable compared to others than they actually are, and—most relevant to the present article—hold unwarranted certainty in the accuracy of their beliefs (Porter et al., 2021). Overconfidence in one's beliefs and opinions is problematic because it leads to poor decisions based on false beliefs, causes individuals to reject accurate information that contradicts their existing beliefs, and generates unnecessary disagreements and conflicts with others. Simply put, individuals high in intellectual humility understand that they can never fully know what they do not know (Leary, 2022).

Flexibility is a personality trait that describes the extent of an individual's ability to cope with changes in circumstances and to think about problems and tasks in novel and creative ways. This trait comes into play when stressors or unexpected events occur, requiring the individual to alter their stance, perspective, or commitment. Flexibility, or psychological flexibility, is the ability to

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adapt to situational demands, balance life's demands, and commit to behaviors. The American Psychological Association defines cognitive flexibility as the capacity for objective appraisal and appropriately flexible action. Cognitive flexibility also implies adaptability and fair-mindedness. Furthermore, cognitive flexibility varies across an individual's lifespan (American Psychological Association, 2022).

More specifically, researchers have described cognitive flexibility as the capacity to shift or alternate thinking and attention between different tasks or operations, typically in response to a change in rules or demands. Broadly speaking, cognitive flexibility has been described as the ability to adjust one's thinking from old situations to new ones, as well as the ability to overcome habitual responses or thoughts and adapt to novel situations. Thus, if someone can overcome their prior beliefs or habits (when necessary for new situations), they are considered cognitively flexible. Similarly, curiosity can generally be defined as the recognition, pursuit, and desire to explore novel, uncertain, complex, and ambiguous events. In situations where there is a potential for learning, a feeling of interest arises. There is a tendency to seek out novel experiences to see what happens, to figure out how one reacts, or to discover how others respond. Given this definition, curiosity shares commonalities with a bewildering array of psychological terms such as openness to experience, novelty seeking, need for cognition, intrinsic motivation, tolerance of ambiguity, tolerance of uncertainty, frustration tolerance, and sensation seeking. Any researcher or practitioner interested in curiosity will encounter separate lines of research with different terminologies describing a similar set of emotions and behaviors. Synthesis is needed, and this will only be possible through a clear demarcation of the core features of curiosity (Kashdan et al. [3]). William James (1890) was the first to propose that curiosity is a fundamental psychological drive and provided an argument for more than one dimension. Although curiosity is pervasive in daily life and in psychological models of motivations and strengths, it has rarely been empirically studied as a multidimensional individual difference variable. Often, curiosity is examined as a single, global dimension (Mussel, 2013).

Since the inception of psychology, curiosity has held a central place in the study of motivation, emotion, and cognition, as well as in broad disciplines such as biology, economics, robotics, and leadership. Theorists have disagreed on the fundamental principles of curiosity; some researchers

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argue that rewards are generated when ambiguity and uncertainty are resolved, whereas others contend that being curious is an intrinsically rewarding experience (Kashdan et al., 2018).

For over 100 years, curiosity has been rigorously examined in psychological studies. Researchers believe that curiosity is vital for human survival and growth. Curious individuals are known for asking a multitude of spontaneous questions, reading deeply, examining interesting images, manipulating fascinating objects, observing how others think, feel, and behave, taking risks to acquire novel experiences, and persisting in challenging tasks. Altogether, there is a consensus that the immediate function of curiosity is seeking, exploring, and immersing oneself in situations that hold the potential for acquiring novel information or experiences.

In the long term, consistently acting on feelings of curiosity leads to the expansion of knowledge, the development of competencies, the strengthening of social relationships, and the enhancement of intellectual and creative capacities (von Stumm & Ackerman, 2013).

The purpose of this study was to investigate the relationship of personality traits, flexibility, and curiosity with intellectual humility in order to propose a structural equation model among students at the Islamic Azad University, Bandar Abbas Branch.

Material and Methods

Research Design and Participants

In terms of purpose, this is an applied research study, and the data collection method is survey-based. Methodologically, it employs a psychometric approach and structural equation modeling (SEM). Specifically, the validity of the Intellectual Humility index is examined based on Classical Test Theory (CTT) and Item Response Theory (IRT), and the fit of the structural equation model assessing the effects of psychological flexibility, personality traits, and curiosity and exploration on intellectual humility was evaluated.

The mechanism of structural equation modeling is such that it serves as a highly general and powerful multivariate analysis technique from the multivariate regression family. Strictly speaking, it is an extension of the General Linear Model, which allows the researcher to test a set of regression equations simultaneously. SEM is a comprehensive approach for testing hypotheses regarding the relationships between manifest (observed) and latent (unobserved) variables.

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Structural equation modelling comprises a diverse set of methods utilized by scientists for observational and experimental research.

According to a standard definition, structural equation modeling is "a class of methodologies that seeks to represent hypotheses about the means, variances, and covariances of observed data in terms of a smaller number of 'structural' parameters defined by a hypothesized underlying conceptual or theoretical model." SEM involves a method that demonstrates how various aspects of a phenomenon are causally related to one another. Structural equation models often contain hypothesized causal connections between certain latent variables (variables that are theorized to exist but cannot be directly observed). Additional causal connections link these latent variables to observed variables, whose values appear in a dataset.

Causal structures imply that specific patterns should emerge among the values of the observed variables. This enables the use of associations between the values of observed variables to estimate the magnitude of hypothesized effects and to test whether the observed data are consistent with the requirements of the hypothesized causal structures (Kline, 2016). A major advantage of structural equation modeling is that all these measurements and tests occur simultaneously in a single statistical estimation procedure, in which all model coefficients are calculated using all the information from the observed variables. This means that the estimates are more accurate than if a researcher were to calculate each part of the model separately (Tarka, 2017).

Instruments

The Intellectual Humility Scale by Krumrei and Rouse (2016):

The Intellectual Humility Scale by Krumrei and Rouse (2016) is a 22-item scale rated on a 5-point Likert scale (from *strongly disagree* to *strongly agree*) that measures individuals' levels of receptiveness and intellectual humility (e.g., "I am open to revising my important beliefs in the face of new information."). This scale consists of four factors: Independence of Intellect and Ego (5 items), Openness to Revising One's Viewpoint (5 items), Respect for Others' Viewpoints (6 items), and Lack of Intellectual Overconfidence (6 items). This scale demonstrates good internal consistency, test-retest reliability, and construct validity (Alfano et al., 2017).

Based on the findings reported by Krumrei and Rouse (2016), participants across the United States were recruited via MTurk. The dataset was randomly split into two halves (380 individuals each) to be utilized in Study 1 and Study 2. Participants in Study 1 comprised 56% males and 44%

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females, aged between 18 and 71 years. The sample identified as 77% Caucasian, 9% Asian, 8% Hispanic, 4% Black or African American, and 2% other. Regarding the highest level of completed education, 36% had completed high school, 56% college, and 8% postgraduate studies.

Utilizing an Exploratory Factor Analysis (EFA) solution to achieve a relatively concise measure, a maximum of 6 items per factor with the highest factor pattern and structure coefficients (at least .40) were selected, and items with factor pattern cross-loadings greater than .30 were removed. Factor structure cross-loadings exceeded .30 in some instances. However, items with the greatest distance between the two factor structure coefficients were retained. Principal axis factoring of the 22 selected items yielded a KMO of .89 and a significant Bartlett's test of sphericity, $\chi^2(231) = 3458.65, p < .001$. All items continued to load on their respective factors. The four factors accounted for 57.24% of the total variance and 48.25% of the common variance. As expected, there were correlations among the factors, ranging from .31 to .67. The alpha coefficient was .88 for the full scale and ranged from .73 to .89 for the subscales.

In this study, the Intellectual Humility Scale by Krumrei and Rouse (2016) was utilized in Iran for the first time. Using the Waltz and Bausell method, the Content Validity Ratio (CVR) for the intellectual humility construct was calculated as .97. Furthermore, the Content Validity Index (CVI) was calculated as .95 for the clarity of all items, .96 for simplicity, and .97 for relevance.

The assumption of local independence was satisfied based on Pearson's χ^2 index by applying Samejima's Graded Response Model (GRM) within the Item Response Theory (IRT) framework. Additionally, the unidimensionality assumption was confirmed through Multidimensional Item Response Theory (MIRT) analysis and Exploratory Factor Analysis (EFA) using the principal axis factoring method. Based on both Classical Test Theory (CTT) and the item parameters of the Graded Response Model, the items were found to be optimal.

The factor loadings of the items ranged between +.60 and +.92, with item 7 exhibiting the lowest and item 19 exhibiting the highest factor loading. Specifically:

- **Independence of Intellect and Ego:** Item 4 had the lowest (+.65) and item 1 had the highest (+.85) loading.
- **Respect for Others' Viewpoints:** Item 7 had the lowest (+.60) and item 11 had the highest (+.86) loading.

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- **Openness to Revising One's Viewpoint:** Item 16 had the lowest (+.69) and item 13 had the highest (+.75) loading.
- **Lack of Intellectual Overconfidence:** Item 20 had the lowest (+.61) and item 19 had the highest (+.92) loading.

The item information function yielded the maximum information around the average theta (θ). The highest information value for the Independence of Intellect and Ego component belonged to item 1, with the component's maximum information falling within the range of 0 to +1.6. For the Respect for Others' Viewpoints component, item 11 yielded the highest information, peaking in the range of -0.8 to +1.6. For Openness to Revising One's Viewpoint, item 13 provided the highest information, maximizing in the range of -2.8 to +0.8. Finally, for Lack of Intellectual Overconfidence, item 19 had the highest information, with the component's peak information occurring in the range of -2.0 to +1.6.

To estimate reliability, empirical or marginal reliability was employed. Given that the standard error of measurement varies across assessed individuals in the Item Response Theory framework, the results demonstrated that the marginal reliability coefficients derived from IRT were .80 for Independence of Intellect and Ego, .86 for Respect for Others' Viewpoints, 0.81 for Openness to Revising One's Viewpoint, and 0.90 for Lack of Intellectual Overconfidence.

Furthermore, the internal consistency of the items was evaluated based on Classical Test Theory (CTT). The 22 items were analyzed simultaneously to determine their internal consistency reliability. The results indicated a total reliability coefficient of 0.899. The reliability coefficients for the subscales were calculated as follows: 0.827 for Independence of Intellect and Ego (5 items), 0.846 for Respect for Others' Viewpoints (6 items), 0.778 for Openness to Revising One's Viewpoint (5 items), and 0.843 for Lack of Intellectual Overconfidence (6 items).

The Psychological Flexibility Questionnaire (PFQ):

The Psychological Flexibility Questionnaire (PFQ) was developed by Ben-Itzhak et al. (2014). The questionnaire consists of 20 items scored on a 6-point Likert scale (ranging from 1 = *never* to 6 = *very much*), with the total score ranging from 24 to 124. A higher score on this questionnaire indicates greater psychological flexibility. Furthermore, it comprises five subscales: Positive Perception of Change (5 items), Characterization of the Self as Flexible (5 items), Characterization

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of the Self as Open and Creative (3 items), Perception of Reality as Dynamic and Changeable (4 items), and Perception of Reality as Multifaceted (3 items).

Its reliability and validity were evaluated in a study by Safraei et al. (2020), wherein 400 male and female students from Ferdowsi University of Mashhad were selected via a multi-stage cluster random sampling method during the 2019-2020 academic year and completed the PFQ. To assess construct validity, Exploratory and Confirmatory Factor Analyses (EFA and CFA) were employed. The factor analysis results revealed that this questionnaire consists of five factors, which collectively explained 59.83% of the total variance. The internal consistency of the PFQ items yielded a Cronbach's alpha coefficient of 0.89, indicating the optimal reliability of this instrument. Based on the EFA and CFA results in that study, the PFQ demonstrates acceptable validity and reliability among university students.

In the current study, the internal consistency was calculated, yielding a Cronbach's alpha of 0.836.

The NEO Five-Factor Inventory (NEO-FFI):

The NEO Five-Factor Inventory (NEO-FFI) is a successor to the NEO test, developed by McCrae and Costa in 1985. This questionnaire measures five main personality factors using 60 items, which include:

1. **Agreeableness:** Reflects individual characteristics such as empathy, altruism, kindness, cooperation, and satisfaction.
2. **Conscientiousness:** Identifies individual differences in punctuality, determination, orderliness, respectfulness, and reliability.
3. **Extraversion:** Examines individual differences in sociability, assertiveness, and positive emotions.
4. **Neuroticism:** Indicates the degree of stress, negative emotions, and low self-esteem.
5. **Openness to Experience:** Reflects individual differences in innovation, curiosity, and social attitudes.

Responses are rated on a 5-point Likert scale (*strongly disagree*, *disagree*, *neutral*, *agree*, and *strongly agree*). The scoring for the NEO-FFI items is not uniform; some items are reverse-scored (i.e., *strongly disagree* = 4, *disagree* = 3, *neutral* = 2, *agree* = 1, and *strongly agree* = 0), whereas other items are directly scored in the opposite manner.

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The NEO-FFI was administered by McCrae and Costa to 208 American university students with a three-month interval, yielding test-retest reliability coefficients ranging from 0.75 to 0.83. The long-term reliability of this questionnaire has also been evaluated. A 6-year longitudinal study on the Neuroticism, Extraversion, and Openness to Experience scales demonstrated reliability coefficients ranging from 0.68 to 0.83 in both self-reports and spouse reports. The reliability coefficients for Agreeableness and Conscientiousness over a two-year interval were 0.79 and 0.63, respectively (McCrae & Costa, 1983, as cited in Garousi Farshi, 2001).

In the standardization of the NEO test conducted by Garousi Farshi (2001) on a sample of 2,000 university students from Tabriz, Shiraz, and the medical universities of these two cities, the correlation coefficients for the five main dimensions were reported to range between 0.56 and 0.87. Cronbach's alpha coefficients for Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness were 0.86, 0.73, 0.56, 0.68, and 0.87, respectively. To assess the validity of this test, the correlation between the self-report form (Form S) and the observer rating form (Form R) was evaluated, with the maximum correlation being 0.66 for Extraversion and the minimum being 0.45 for Agreeableness (Garousi Farshi, 2001).

In a study by Atashrouz (2007), utilizing the internal consistency method, Cronbach's alpha coefficients for the five traits—Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness—were obtained as 0.74, 0.55, 0.27, 0.38, and 0.77, respectively.

In the current study, the internal consistency was calculated, yielding a Cronbach's alpha coefficient of 0.861.

The Curiosity and Exploration Inventory (CEI-II):

The Curiosity and Exploration Inventory (CEI-II) was developed by Kashdan et al. (2009) across George Mason University, the University of Kansas, the University of North Carolina at Greensboro, and the University of Colorado in the United States. This 10-item questionnaire—which is the revised and advanced version of the original Curiosity and Exploration Inventory—was designed and standardized to assess individual differences in the recognition, pursuit, and integration of novel and challenging experiences. It comprises two factors: "Stretching" and "Embracing". The internal consistency of the items, calculated using Cronbach's alpha, was 0.79 for Stretching, 0.75 for Embracing, and 0.85 for the total scale (Kashdan et al., 2009).

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The translation and standardization of this scale among high school students in Isfahan were conducted by Farsani, Zafarizadeh, and Bahrami (2016). In their study, data analysis was performed utilizing internal consistency, concurrent and discriminant validity, as well as exploratory and confirmatory factor analyses. The factor analysis results indicated two factors—labeled "Exploration" and "Absorption"—which collectively explained 68.25% of the questionnaire's total variance. Furthermore, the findings revealed that the alpha coefficients for the two factors ranged from 0.78 to 0.83, with the total scale yielding an alpha coefficient of 0.84. Its correlation with the Rosenberg Self-Esteem Scale was 0.27 ($p < .001$).

Given the optimal validity and reliability of this scale, it can be utilized to measure curiosity and exploration traits within the general population. In the present study, the internal consistency was calculated, yielding a Cronbach's alpha coefficient of 0.894.

Ethical Considerations

This study was conducted in strict accordance with the ethical principles for human research outlined by the American Psychological Association (APA) and the Declaration of Helsinki. Prior to participation, the research protocol and data collection procedures were approved by the institutional review board and ethics committee. Informed consent was obtained from all participants prior to data collection, ensuring that they were fully informed about the research objectives, the voluntary nature of their participation, and their right to withdraw from the study at any time without penalty. Participants were also assured of absolute confidentiality and anonymity, as data were collected and analyzed anonymously without recording any personally identifiable information.

Results

To determine the face validity of the Intellectual Humility Scale, the opinions of eight psychology experts were solicited regarding aspects such as wording, comprehensibility, desirability, and the avoidance of technical jargon in the items; based on their feedback, necessary modifications were implemented. Subsequently, after presenting the Intellectual Humility Scale to the eight psychology experts to assess the Content Validity Ratio (CVR), each item was rated on a three-point continuum (0 = *not necessary*, 1 = *useful but not essential*, 2 = *essential*). The CVR for the intellectual humility construct was calculated as .97. Furthermore, the Content Validity Index

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(CVI) was obtained, yielding values of 0.95 for the clarity of all items, 0.96 for simplicity, and 0.97 for relevance.

Before examining the research questions, the overall condition of the data was evaluated. First, out-of-range data were identified, and necessary corrections regarding data entry were made. Next, missing data were examined, and questionnaires with more than 5% missing responses to the items were excluded from the analysis. After verifying the statistical assumptions, the final data analysis for the research questions was conducted on a sample of 492 participants.

Table 1. Descriptive Statistics, Slope, and Reliability Coefficients of the Intellectual Humility Items

Component	Item	Mean	Standard deviation	Slope	Cronbach's alpha	Component	Item	Mean	Standard deviation	Slope	Cronbach's alpha
Intellectual Independence	1	1.80	1.275	.470	.896	Openness to revising viewpoints	۱۲	3.91	1.007	.668	.891
	2	2.19	1.358	.548	.893		۱۳	3.78	1.039	.660	.891
	3	2.13	1.324	.472	.896		۱٤	3.47	1.034	.657	.891
	4	2.67	1.360	.528	.894		۱٥	3.61	1.013	.695	.890
	5	2.70	1.449	.495	.895		۱٦	3.76	.960	.624	.892
Respect for others' viewpoints	6	2.36	1.216	.509	.894	Intellectual overconfidence	۱۷	2.53	1.045	.326	.899
	7	1.76	1.070	.390	.899		۱۸	3.01	1.043	.586	.893
	8	1.95	1.039	.407	.899		۱۹	3.05	1.012	.571	.893
	9	2.07	1.179	.492	.895		۲۰	3.11	.988	.439	.896
	10	2.31	1.276	.423	.897		۲۱	3.13	1.031	.625	.892
	11	2.36	1.160	.429	.896		۲۲	3.06	.889	.537	.894

According to the results presented in Table 1, the item discrimination parameters of the intellectual humility items, based on Classical Test Theory (CTT), ranged between +0.326 and +0.695. Item 17 exhibited the lowest discrimination parameter, while item 15 demonstrated the highest. Specifically:

- For the **Independence of Intellect and Ego** component, item 2 had the highest (0.548) and item 1 had the lowest (0.470) discrimination parameter.
- For the **Respect for Others' Viewpoints** component, item 6 had the highest (0.509) and item 7 had the lowest (0.390) discrimination parameter.
- For the **Openness to Revising One's Viewpoint** component, item 15 had the highest (0.695) and item 16 had the lowest (0.624) discrimination parameter.
- For the **Lack of Intellectual Overconfidence** component, item 21 had the highest (0.625) and item 17 had the lowest (0.326) discrimination parameter.

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Consequently, the item discrimination parameters of the Intellectual Humility Scale based on CTT were optimal.

The internal consistency reliability of the items, based on CTT, was calculated in two ways. First, all 22 items were analyzed simultaneously, yielding a total reliability coefficient of 0.899. In the second approach, the reliability was examined based on the constituent factors of the Intellectual Humility Scale. The reliability coefficients were calculated as 0.827 for Independence of Intellect and Ego (5 items), 0.846 for Respect for Others' Viewpoints (6 items), 0.778 for Openness to Revising One's Viewpoint (5 items), and 0.843 for Lack of Intellectual Overconfidence (6 items). Furthermore, the contribution of each item to the internal consistency was evaluated using an item-deleted analysis. The results indicated that for no component did the deletion of an item result in an increase in the internal consistency of that component. Therefore, all items within each component are homogeneous and exhibit a strong correlation with their respective components. In conclusion, the items of the Intellectual Humility Scale demonstrated optimal reliability based on Classical Test Theory.

Item Analysis Based on the Graded Response Model (GRM)

In this section, the psychometric properties of the Intellectual Humility Scale were evaluated using the Graded Response Model (GRM). The GRM is capable of analyzing categorical responses along an ordinal continuum, such as a Likert scale, where respondents' attitudes or inclinations are assessed using a single statement accompanied by multiple response categories. In this context, the attitudes and opinions of the respondents are expressed as discrete categories along a continuum.

The GRM assumes that an item response is an ordinal categorical variable wherein the score categories are not necessarily separated by equal intervals (Lee, 2013). Therefore, given that the response pattern of the Intellectual Humility Scale consists of polytomous, ordered categorical data scored on a Likert scale, the GRM was employed to examine its psychometric properties. Furthermore, to evaluate the assumptions of local independence and unidimensionality, as well as to compute the item information functions for the Intellectual Humility Scale, IRTPRO software was utilized.

Before analyzing the items using Item Response Theory (IRT), it is essential to ensure that the two primary assumptions of IRT are satisfied. These assumptions are local independence and

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unidimensionality. The assumption of local independence posits that if the examinee's ability level is considered the sole primary factor, their responses to the test items are statistically independent of one another. If this assumption holds, an examinee's performance on a given item should not be influenced by their responses to other items (Sijtsma & Molenaar, 2002). Hambleton (2010) asserts that if the unidimensionality assumption is met, the local independence assumption will consequently be satisfied. In fact, by extracting a dominant factor, the covariance between variables approaches zero, and the relationship among items dissipates once this dominant factor is controlled for. According to Cai, du Toit, and Thissen (2011), items with χ^2 index values greater than 10 indicate potential local dependence. Furthermore, based on Thissen, Cai, and Bock (2010), marginal χ^2 values exceeding 10 also suggest a lack of local independence. A violation of local independence implies that the items do not solely load on a single dimension; rather, items with χ^2 values greater than 10 form an additional dimension. Thus, the presence of local dependence among items indicates that a single dimension cannot adequately model the structure of those items. To examine the local independence assumption among the items of the Intellectual Humility Scale, Pearson's χ^2 and marginal χ^2 indices were calculated using IRTPRO software, applying Samejima's Graded Response Model (GRM) and specifying a single dimension for all items of each trait. The calculated values for all items were less than 10, indicating that the assumption of local independence was met. Therefore, in the Intellectual Humility Scale, the response to each item is independent, and no item influences the response (or lack thereof) to other items. Another fundamental assumption of IRT is unidimensionality, meaning there is a dominant underlying factor that accounts for the factor loadings on most of the test items and dictates the selection of item response categories. In other words, all test items should measure only a single domain of ability or knowledge. A violation of this assumption leads to bias in parameter estimation (Reckase, 2009). To evaluate the unidimensionality assumption of the Intellectual Humility Scale, Multidimensional Item Response Theory (MIRT) analysis was employed. In this approach, three models (unidimensional, two-dimensional, and three-dimensional) were analyzed to infer the dimensionality of the test by comparing their relative fit. Based on the calculated results for the Intellectual Humility Scale, the log-likelihood for the first model was smaller than that of the other two models, indicating a better fit. Additionally, this model reached convergence with fewer iterations, which further supports the superior fit of the unidimensional model. Subsequently, the

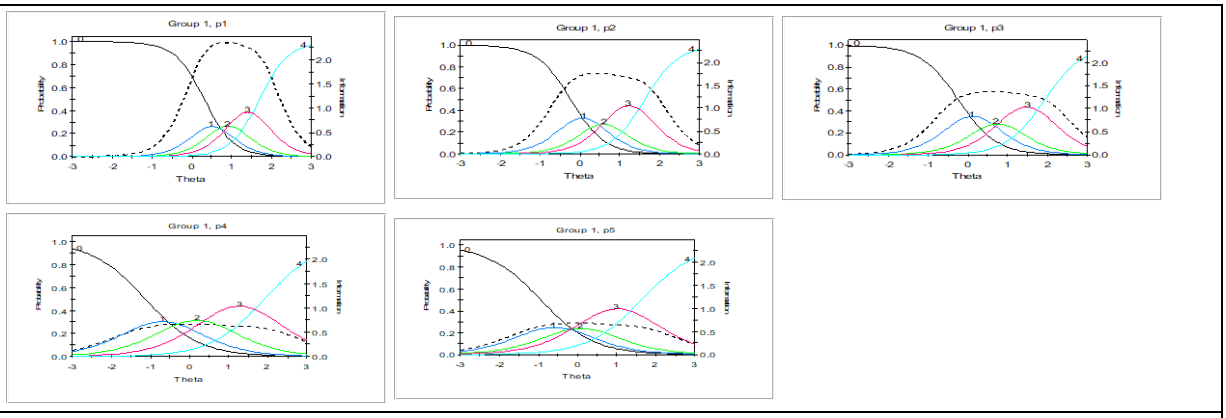
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three models were compared. The calculated χ^2 statistics for the comparison between the unidimensional and two-dimensional models, as well as between the unidimensional and three-dimensional models, revealed a significant difference. Furthermore, the Akaike Information Criterion (AIC) and the Sample-Size Adjusted Akaike Information Criterion (AICS) were larger in the unidimensional model compared to the two- and three-dimensional models. Therefore, the unidimensional model demonstrates a better fit compared to the multidimensional models, confirming the unidimensionality of the Intellectual Humility Scale. After ensuring the local independence and unidimensionality of the data matrix, the Graded Response Model was estimated using IRTPRO software. The results of this analysis are reported in Table 2.

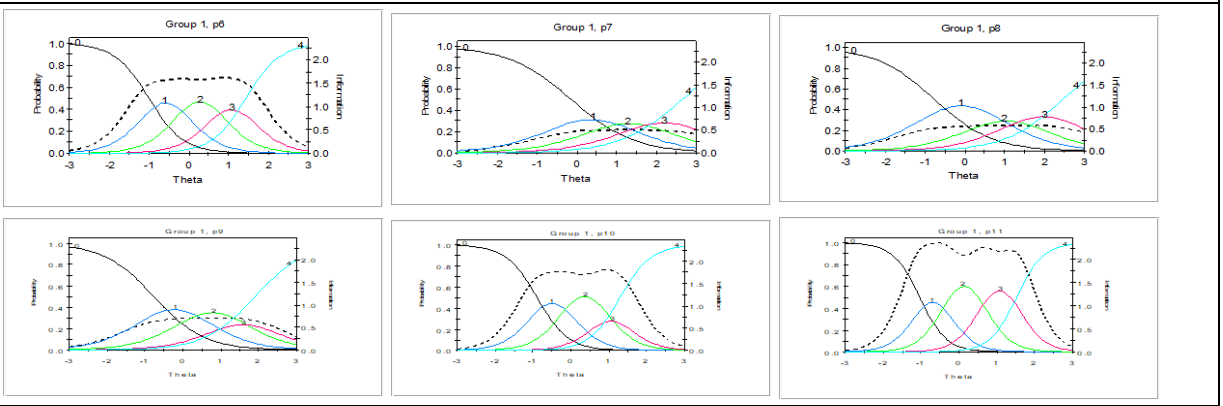
Table 2. Item Parameters of the Intellectual Humility Scale Based on the Graded Response Model

Component	Item	A	b1	b2	b3	b4	λ	Component	Item	A	b1	b2	b3	b4	λ
Intellectual independence	1	2.73	0.31	0.71	1.11	1.70	0.85	Openness to revising viewpoints	١٢	1.87	-3.19	-2.23	-0.94	0.60	0.74
	2	2.37	-0.23	0.35	0.83	1.63	0.81		١٣	1.95	-2.96	-1.96	-0.69	0.81	0.75
	3	2.09	-0.23	0.47	1.03	1.92	0.78		١٤	1.63	-3.18	-1.56	-0.22	1.40	0.71
	4	1.45	-1.13	-0.27	0.63	1.92	0.65		١٥	1.86	-3.11	-1.84	-0.47	1.08	0.74
	5	1.47	-0.94	-0.25	0.42	1.63	0.67		١٦	1.61	-4.07	-2.19	-0.60	0.99	0.69
Respect for others' viewpoints	6	2.33	-1.00	-0.16	0.71	1.43	0.81	Intellectual overconfidence	١٧	2.10	-1.47	0.13	1.17	2.12	0.78
	7	1.28	-0.14	0.87	1.74	2.64	0.60		١٨	3.64	-1.79	-0.76	0.42	1.61	0.91
	8	1.38	-0.77	0.60	1.47	2.47	0.63		١٩	4.11	-1.88	-0.78	0.38	1.57	0.92
	9	1.51	-0.76	0.29	1.26	1.90	0.66		٢٠	1.37	-2.75	-1.08	0.46	2.65	0.61
	10	2.45	-0.89	-0.10	0.83	1.29	0.82		٢١	1.64	-2.25	-1.15	0.21	2.23	0.70
	11	2.85	-1.03	-0.34	0.63	1.52	0.86		٢٢	1.38	-2.80	-1.47	0.63	3.32	0.63

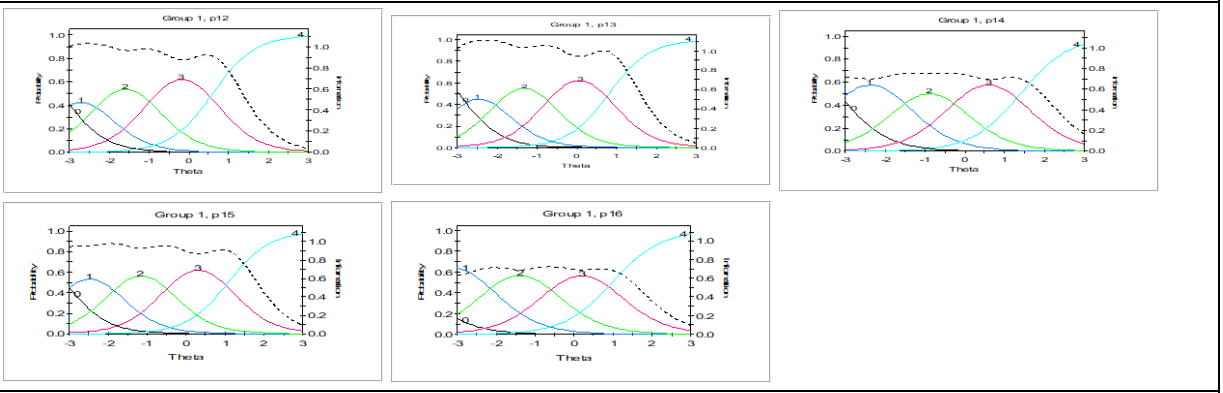
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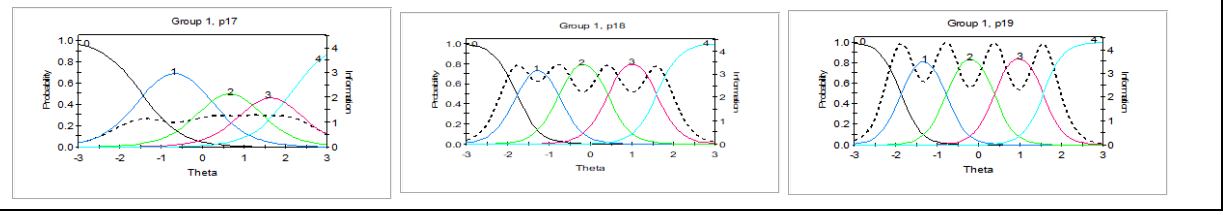
Intellectual independence component



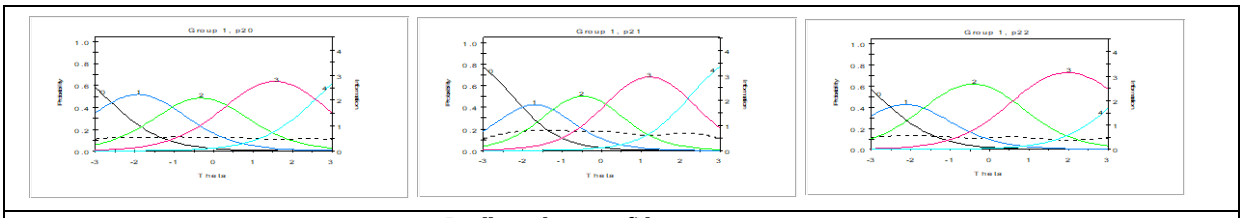
Respect for others' viewpoints component



Openness to revising viewpoints component



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Intellectual overconfidence component

Figure 1. Information Functions and Item Response Curves for the Intellectual Humility Components

An examination of the item fit indices based on the Graded Response Model (GRM) revealed that the calculated chi-square (χ^2) significance levels for all items were greater than 0.05, indicating good fit indices for these items. The discrimination parameters for the items of the total scale ranged from +1.28 to +4.11. Specifically, the discrimination parameters ranged from +1.45 to +2.73 for the Independence of Intellect and Ego component, from +1.28 to +2.85 for the Respect for Others' Viewpoints component, from +1.61 to +1.95 for the Openness to Revising One's Viewpoint component, and from +1.37 to +4.11 for the Lack of Intellectual Overconfidence component.

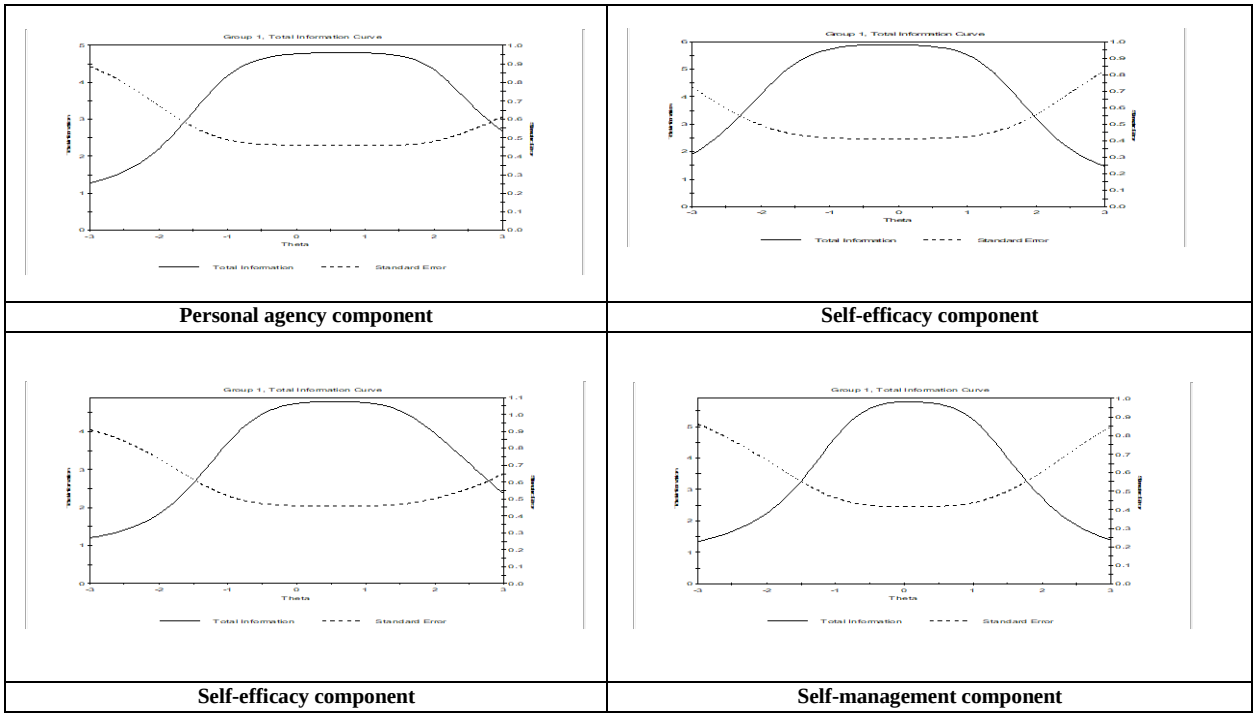
Furthermore, the first between-category threshold parameter ranged from -4.07 to 0.31, the second threshold parameter ranged from -2.23 to +0.87, the third threshold parameter ranged from -0.94 to +1.74, and the fourth between-category threshold parameter ranged from +.60 to +3.32. Based on the findings reported in Table 4-13 and Figure 4-1, the category response curves exhibit a good order, such that their distributions are clearly distinguishable from one another. Additionally, the curves do not display flatness and are not entangled. The thresholds for the response categories of all items are sufficiently spaced so that no category is entirely subsumed by another. The response categories independently possess a probability of being endorsed by individuals across specific ranges of theta (θ), demonstrating the efficacy of the scoring scale.

The factor loadings of the items ranged between +0.60 and +0.92, with item 7 exhibiting the lowest and item 19 the highest factor loading. Specifically:

- **Independence of Intellect and Ego:** Item 4 had the lowest (+0.65) and item 1 had the highest (+0.85) loading.

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- **Respect for Others' Viewpoints:** Item 7 had the lowest (+0.60) and item 11 had the highest (+0.86) loading.
- **Openness to Revising One's Viewpoint:** Item 16 had the lowest (+0.69) and item 13 had the highest (+0.75) loading.
- **Lack of Intellectual Overconfidence:** Item 20 had the lowest (+.61) and item 19 had the highest (+0.92) loading.



Personal agency component	Self-efficacy component
Self-efficacy component	**Self-management component**

Figure 2. Test Information Functions for the Intellectual Humility Components

Based on the results reported in Table 4-11 and Figure 4-2, the information function yields the maximum information around the average theta (θ). The highest information value for the Independence of Intellect and Ego component belonged to item 1, with the component's maximum information falling within the range of 0 to +1.6. For the Respect for Others' Viewpoints component, item 11 yielded the highest information, peaking in the range of -0.8 to +1.6. For Openness to Revising One's Viewpoint, item 13 provided the highest information, maximizing in the range of -2.8 to +0.8. Finally, for the Lack of Intellectual Overconfidence component, item 19

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had the highest information, with the component's peak information occurring in the range of -2.0 to +1.6. The remaining items also demonstrated an optimal level of information.

To estimate reliability, empirical or marginal reliability was employed. Given that the standard error of measurement varies across assessed individuals in the Item Response Theory (IRT) framework, the results demonstrated that the marginal reliability coefficients derived from IRT were 0.80 for Independence of Intellect and Ego, 0.86 for Respect for Others' Viewpoints, 0.81 for Openness to Revising One's Viewpoint, and 0.90 for Lack of Intellectual Overconfidence.

Structural Equation Model (Study 2)

Hypothesis Testing: "Psychological flexibility, personality traits, and curiosity and exploration are related to intellectual humility."

To test this hypothesis, LISREL software was utilized. Several criteria are employed to evaluate the fit of the proposed structural model, the first and most fundamental of which is the significance of the *t*-values. The primary criterion for assessing the relationships between the variables within a structural model is the significance of the *t*-statistic. An absolute value exceeding 1.96 indicates a significant relationship between the variables, thereby confirming the research hypothesis at a 95% confidence level. However, it is important to note that while the *t*-statistic establishes the significance of the relationship, the strength of the association between the variables is determined by the path coefficients.

Table 3. Path Coefficients of the Relationships Between Research Variables

Relations	Path coefficient	*t*-value	Result
Between Curiosity and Intellectual Humility	**0.17**	**5.51**	**99% confidence level**
Between Psychological Flexibility and Intellectual Humility	**0.36**	**16.44**	**99% confidence level**
Between Personality Traits and Intellectual Humility	**0.50**	**15.52**	**99% confidence level**
Adjusted R-squared	**0.79**		**99% confidence level**

According to the results presented in Table 3, the path coefficients for the relationships among the variables are statistically significant at the 99% confidence level ($p < .01$), thereby confirming the hypothesized paths. Furthermore, the adjusted R^2 value of .790 indicates that 79% of the variance in intellectual humility is explained by the combination of psychological flexibility, personality traits, and curiosity and exploration. Consequently, the hypothesis stating that "psychological

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flexibility, personality traits, and curiosity and exploration are related to intellectual humility" is fully supported at the 99% confidence level.

Examining the Correlation Coefficients of the Research Variables

To investigate the bivariate relationships of psychological flexibility, personality traits, and curiosity and exploration with intellectual humility, the Pearson correlation coefficient was utilized. The results of this analysis are reported in Table 4.

Table 4. Correlation Matrix of the Research Variables

		flexibility	Personality	curiosity	Intellectual Humility
Flexibility	Pearson Correlation	1	.509**	.427**	.693**
	Sig. (2-tailed)		.000	.000	.000
	N	581	581	581	581
Personality	Pearson Correlation	.509**	1	.788**	.824**
	Sig. (2-tailed)	.000		.000	.000
	N	581	581	581	581
Curiosity	Pearson Correlation	.427**	.788**	1	.723**
	Sig. (2-tailed)	.000	.000		.000
	N	581	581	581	581
Intellectual Humility	Pearson Correlation	.693**	.824**	.723**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	581	581	581	581
**. Correlation is significant at the 0.01 level (2-tailed).					

Examining the First Sub-Hypothesis: "Psychological flexibility is related to intellectual humility." To test this hypothesis, the Pearson correlation test was employed. The results of this analysis are reported in Table 5.

Table 5. Pearson Correlation Coefficient Between Psychological Flexibility and Intellectual Humility

	Psychological flexibility	
Intellectual Humility	Pearson correlation coefficient	0.693
	Significance level	0.001
	Sample size	581

According to the results presented in Table 5, the relationship between psychological flexibility and intellectual humility ($r = 0.693$) is statistically significant at the 99% confidence level ($p < .01$). Therefore, the hypothesis stating that "psychological flexibility is related to intellectual humility" is supported.

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Furthermore, although the correlation coefficient indicates the existence of a relationship between the variables, it does not provide information regarding the extent of their shared variance. Therefore, to determine the proportion of shared variance between the variables, the coefficient of determination ($r^2 \times 100$) is utilized. Given that the correlation coefficient between psychological flexibility and intellectual humility is $r = 0.693$, the coefficient of determination is calculated as $(.693)^2 \times 100 = 48.1\%$. This indicates that approximately 48% of the variance is shared between psychological flexibility and intellectual humility.

Examining the Second Sub-Hypothesis: "Personality traits are related to intellectual humility." To test this hypothesis, the Pearson correlation test was employed. The results of this analysis are reported in Table 5.

Table 6. Pearson Correlation Coefficient Between Personality Traits and Intellectual Humility

	Personality traits	
Intellectual Humility	**Pearson correlation coefficient**	**0.824**
	Significance level	**0.001**
	Sample size	**581**

According to the results presented in Table 6, the relationship between personality traits and intellectual humility ($r = 0.824$) is statistically significant at the 99% confidence level ($p < .01$). Therefore, the hypothesis stating that "personality traits are related to intellectual humility" is supported.

Furthermore, although the correlation coefficient indicates the existence of a relationship between the variables, it does not provide information regarding the extent of their shared variance. Therefore, to determine the proportion of shared variance between the variables, the coefficient of determination ($r^2 \times 100$) is utilized. Given that the correlation coefficient between personality traits and intellectual humility is $r = 0.824$, the coefficient of determination is calculated as $(0.824)^2 \times 100 = 67.9\%$. This indicates that approximately 68% of the variance is shared between personality traits and intellectual humility.

Examining the Third Sub-Hypothesis: "Curiosity and exploration are related to intellectual humility." To test this hypothesis, the Pearson correlation test was employed. The results of this analysis are reported in Table 7.

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Table 7. Pearson Correlation Coefficient Between Curiosity and Exploration and Intellectual Humility

		curiosity and exploration
Intellectual Humility	Pearson correlation coefficient	0.723
	Significance level	0.001
	Sample size	581

According to the results presented in Table 7, the relationship between curiosity and exploration and intellectual humility (r = 0.723) is statistically significant at the 99% confidence level ($p <$ .01). Therefore, the hypothesis stating that "curiosity and exploration are related to intellectual humility" is supported.

Furthermore, although the correlation coefficient indicates the existence of a relationship between the variables, it does not provide information regarding the extent of their shared variance. Therefore, to determine the proportion of shared variance between the variables, the coefficient of determination ($r^2 \times 100$) is utilized. Given that the correlation coefficient between curiosity and exploration and intellectual humility is r = 0.723, the coefficient of determination is calculated as $(0.723)^2 \times 100 = 52.3\%$. This indicates that approximately 52% of the variance is shared between curiosity and exploration and intellectual humility.

Discussion

Undoubtedly, assessments are integral to daily life, making the rigorous validation of measurement instruments crucial. The application of modern measurement theories can significantly assist in achieving these objectives. Given the importance of this construct in individuals' lives and overall life satisfaction, the present study aimed to investigate the relationship between personality traits, psychological flexibility, curiosity, and intellectual humility to propose a structural equation model.

Based on the psychometric analyses, the Intellectual Humility Scale possesses adequate face validity and content validity, the latter confirmed via the Content Validity Ratio (CVR) and the Waltz and Bausell Content Validity Index (CVI). Furthermore, the item parameters and test reliability, evaluated through both Classical Test Theory (CTT) and Item Response Theory (IRT), are at an optimal level. According to the measurement invariance analysis of the Intellectual

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Humility Scale across gender, no differential item functioning (DIF) was observed. Therefore, it can serve as an invariant, uniform, and unbiased instrument for measuring intellectual humility.

It is well-established that when measurement invariance holds, the relationship between the latent variable and the observed variable remains constant across different groups or populations. Consequently, under these conditions, observed differences between groups can be confidently attributed to true differences in the underlying latent trait. Examinees exhibiting higher levels of the measured latent trait are more likely to endorse higher categories on the response continuum, reflecting a direct relationship between the selected response and the underlying construct. In other words, if a factor other than the underlying ability causes differences in the observed performance of individuals across groups, measurement invariance does not hold, and the item or test is considered biased. Within the IRT framework, if item parameters are invariant across two or more populations, the item is considered to exhibit measurement invariance (i.e., it lacks differential item functioning). As a result, the true score on an item for two individuals from different populations with identical latent trait levels will be equal.

The results of the structural equation modeling demonstrated that an acceptable proportion of the variance in intellectual humility is explained by psychological flexibility, personality traits, and curiosity and exploration. Ultimately, the Intellectual Humility Scale can be utilized as a valid and reliable instrument by domestic researchers. It provides a robust framework for assessing the current state of intellectual humility, designing and implementing targeted interventions for its enhancement, and further exploring its associations with other variables.

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Data availability statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics statement

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by the institutional ethics committee. All participants provided informed consent prior to participating in the study, and data collection procedures ensured complete anonymity and confidentiality.

Author contributions

All authors contributed to the study conception and design, material preparation, data collection and analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

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